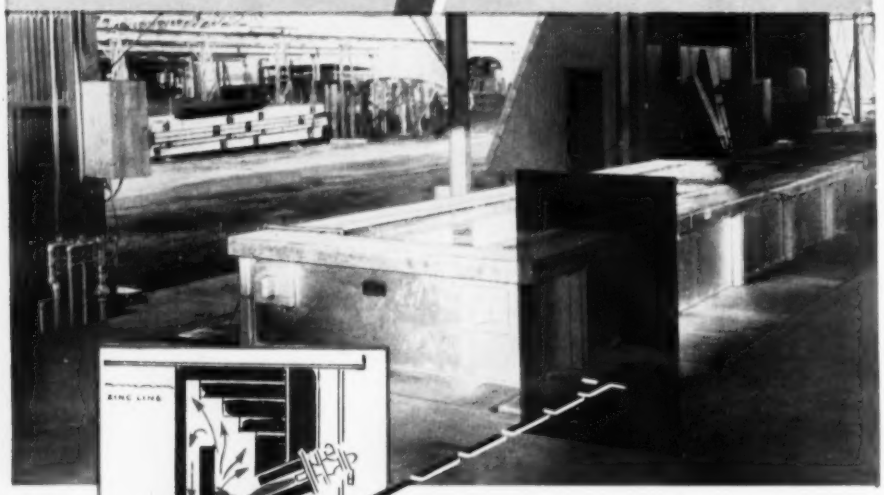
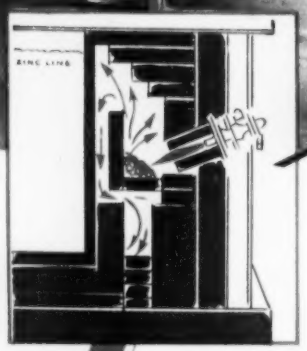
Metal Progress

MARCH - 1953

'Surface'





USED FOR GALVANIZING pails, furnace is set in the floor. Heat from 'Surface' direct-fired burners is thoroughly controlled. Bath temperatures are maintained so that rapid erosion of kettle and hot spots on kettle walls are prevented.

Controlled HIGH HEAT input for your galvanizing operation!

PRECISE, CONTROLLED HIGH HEAT INPUTS are essential for economical batch or continuous galvanizing . . and dependable part and product galvanizing results from a 'Surface' galvanizing furnace, because alloy layer is accurately controlled.

❶ DIRECT-FIRED BURNERS above supply sufficient heat to compensate rapidly for heat losses due to addition of cold work and spelter to bath.

❷ MINIMUM DROSS FORMATION results from the completely uniform and thoroughly distributed heat provided by direct-fired burners. This allows complete, satisfactory adhesion of coating to stock, maximum kettle life.

SETTINGS to meet all batch and continuous production requirements can be supplied.

WHEN NEXT YOU have a galvanizing problem, a 'Surface' industrial engineer will gladly discuss it with you. Better yet, write now for complete information. No obligation, naturally.

SURFACE COMBUSTION *Corporation*

TOLEDO 1, OHIO

'Surface' INDUSTRIAL FURNACES AND BURNERS

Kathabar HUMIDITY CONDITIONING SYSTEMS

Janitrol AUTOMATIC HEATING EQUIPMENT

PRODUCTION BRIEFS

Typical of the jobs being done in galvanizing settings engineered and built by Surface Combustion.

•

BATCH

MALLEABLE FITTINGS

Miscellaneous malleable iron pipe fittings.

Production—3000 lbs/hr., net

Temperature—850 F.

Firing System—14 Low pressure velocity burners firing into refractory beds.

Size (pot)—10½ feet long, 2½ feet wide, 3½ feet deep

•

STEEL WIRE

Steel wire of 0.192 inch diameter

Production—1850 lbs/hr., net

Temperature—875 F.

Firing System—12 Automatic proportioning impact burners, butane gas.

Size (pot)—8 feet long, 3½ feet wide, 2½ feet deep

•

FORMED STEEL PARTS

Hot water tank, gas heater and garbage disposal components.

Production—Varies according to part size and shape.

Temperature—830-850 F.

Firing System—18 Low pressure velocity burners firing into refractory beds.

Size (overall)—14 feet long, 7½ feet wide, 2½ feet deep

•

CONTINUOUS

STEEL STRIP

Light and heavy gage strip 30-48" wide.

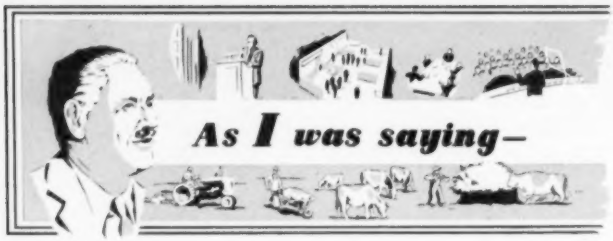
Production—Up to 20,000 lbs/hr., net at speeds from 15 to 300 fpm. Strip passes through radiant tube roller hearth furnace, at 1400-1700 F., through a cooling zone and then directly into galvanizing spelter. Complete line is automatic and operations synchronized.

Size—Total length 222 feet

IN THIS ISSUE

The front cover was designed by Floyd Craig around the "Staircase of Honor" in the new French research institute described in the article on page 83. Photograph by J. P. Schwartz of Paris.

• **See** *Bill's Column on the other side* ➡



IT'S MIGHTY FORTUNATE that when I became a columnist I was assigned to a monthly publication and given a limited amount of space. Even under these favorable conditions the editorial and production departments keep me constantly reminded that the first of the month is "coming 'round the mountain". So here I am, on Feb. 2, notating some thoughts that will not feel printer's ink until early in March nor will it be visible to you (and for that you may be truly thankful) until *Metal Progress* is in your living room.

Eighty-five per cent of the A.S.M. members receive *Metal Progress* at home, and that, to my way of thinking, is the real answer to why MP is so thoroughly enjoyed by all and why those advertisers using its pages are so splendidly repaid. (Why not write for a rate card?)

Right now the Western Metal Congress and Exposition, March 23-27, is funneling into jet activity, ready to burst at the seams with splendid technical sessions and the largest industrial exposition (there you go again Bill, but it's true) ever held in the West. I'll give you a report next month on this activity, a report which I'll write on the last day of March when headin' on the friendly SP for Cleveland and final preparations for a trip to London and the Continent.

This column sure jumps around. Now, in the Golden West, next you are overseas, and how I wish you could all be with me. (I will need someone to call out the stations and point out the places of interest as the Queen Elizabeth glides from New York to Southampton.)

The hope that you might be with me is not such an idle or impossible thought after all. And here is why: The Iron and Steel Institute and the Institute of Metals of Great Britain are jointly issuing invitations to the learned metallurgical societies of Britain and the Continent to send representatives to London during the annual meeting of the Institutes, April 30 and May 1. These representatives will form a committee to make plans for holding a second World Metallurgical Congress in Europe in 1955 or 1956.

In response to an invitation to the A.S.M., the Board directed that I should represent the Society and its 23,000 members at this conference. With the proposed W.M.C. initiated under such distinguished sponsorship as the British Institutes and other great technical associations, its success is assured.

So, as I noted above, there's a reason and many of them why you should begin planning *now* to attend this second gathering of the Metal Scientists of the Free World.

This jump from the Golden West to way over East is checkering me out of a month's quiet vacation in Palm Springs (after 35 years' service we all do or should get a month). It has been 27 years since I was overseas and so when the trustees said, "You'd better go," I made a beeline for the steamship office and made a deposit on a reservation before the Board would have a chance to change its collective mind.

Truly, I am delighted at the opportunity to greet and meet many of the A.S.M. members abroad, to confirm the strong friendship with the overseas' conferees made during the first W.M.C., to meet the distinguished officials and representatives of the metallurgical societies abroad, and finally to endeavor in some sincere way to have them know how greatly we in America recognize and appreciate their outstanding contributions to metallurgical science. All of us will look forward with extreme pleasure to joining with them in a World Congress.

Cordially yours,

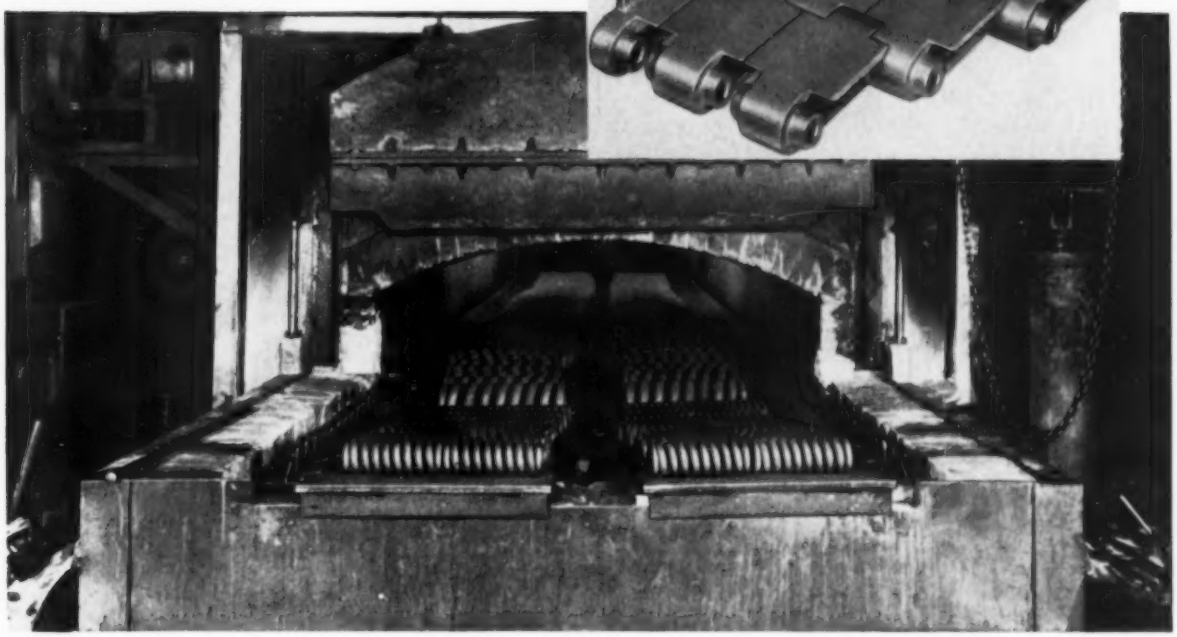
Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

NEW CONVEYOR DESIGN

offers extra heat-treat advantages . . .

- *extra* strength
- *extra* loading capacity
- *extra* long service



This new conveyor belt† was designed to carry loads not possible with conventional style belts. It does not replace conventional cast belts, but serves to widen the field to applications involving extreme temperature and loading conditions formerly unattainable with ordinary belts.

The new Thermalloy staggered-link, conveyor design shown above offers you these features:

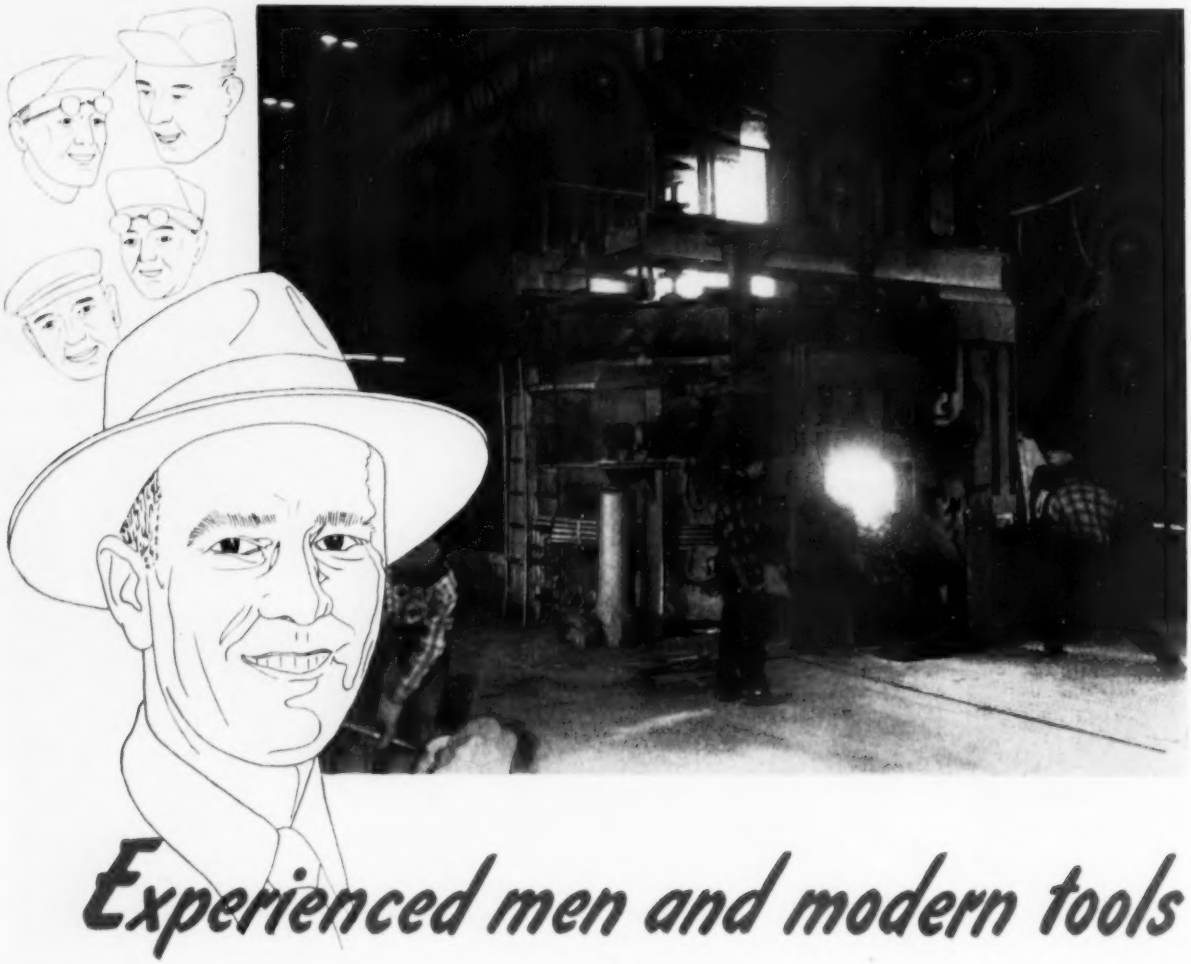
1. Elimination of crank-shafting.
2. A free-floating link which can adjust itself to meet localized stresses.
3. The substitution of strong, wear-resistant, cast-in pins for the weaker wrought pins.

For complete information on this new Thermalloy conveyor belt, standard belts or other furnace parts, contact your nearest Electro-Alloys representative. Or write Electro-Alloys Division, 4002 Taylor Street, Elyria, Ohio.

*Reg. U.S. Pat Off. †Pat. Applied For

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO



Experienced men and modern tools

make Finkl steels the finest

Whether it's 35 tons of special alloy analysis or a quality carbon heat, the experience of steel men like Dave, Bruce, Roy, Lennie, and Chick plus modern tools such as the new electric furnaces shown above combine to make Finkl steels the finest available.

Each heat is constantly checked and carefully controlled, for here is where Finkl quality begins. Here is where we start proving that the finest product is the least expensive to you in the long run.

Since 1879, Finkl has developed many special analysis steels of their own through the desire to constantly improve and to produce the finest die blocks and forgings at the lowest cost to you.

A. Finkl & Sons Co.

2011 SOUTHPORT AVENUE · CHICAGO 14

ELECTRIC FURNACE STEELS · DIE BLOCKS · FORGINGS

In appearance, the 8657-C Indicator is typical of L&N portable test sets and is outstanding for fully dependable, moderate precision. The portable series also includes instruments for measuring temperature, electrolytic conductivity, electrical resistance and pH.

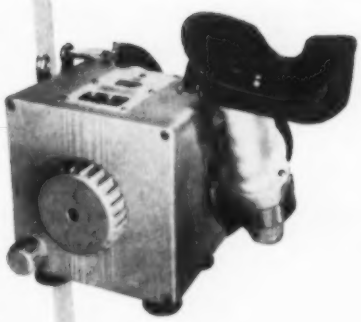
FOR

"on-the-spot" checking...

INVESTIGATE THESE WIDELY-USED TEST SETS

High on any list of "musts" for making spot-checks of production processes and equipment are these L&N Test Sets. For these versatile instruments combine the portability, ruggedness and simplicity of design needed for plant use, with the accuracy and flexibility necessary for use in the laboratory.

Specifications for just a few of these instruments that are particularly useful to the Metal Industry appear below. For more complete information, contact our nearest office or write 4927 Stenton Ave., Phila., Penna.



The 8623 Optical Pyrometer —Direct Reading in degrees, this compact instrument enables users to measure the temperature of molten metals accurately and quickly.

FOR THERMOCOUPLE EMF MEASUREMENT

Instrument	List No.	Range	Limit of Error
Double-Range Portable Millivolt Indicator. For plant use. For thermocouple voltage measurement — reads in millivolts; manual reference junction compensation.	8657-C	Ranges: 0 to 16 mv and 16 to 64 mv. Reference Junction Compensator Ranges: 0 to 1 mv and 0 to 5 mv.	Low Range: ±0.03 mv. High Range: ±0.15 mv.
Double-Range Portable Millivolt Indicator. For Laboratory use. A more precise instrument for uses similar to 8657-C.	8662	Ranges: 15 x 1 mv ±1.1 mv slidewire 15 x 5 mv ±5.5 mv slidewire Reference Junction Compensator Ranges 0 to 1 and 0 to 5 mv.	Low Range: ±0.01 mv. High Range: ±0.05 mv.

FOR pH AND REDOX MEASUREMENT

Stabilized pH Indicator — for direct reading in pH, also for redox measurements. May be used in grounded or ungrounded solutions. For 115-volts, 60 or 50 cycles supply. Portable, Battery operated Model is No. 7662.	7664	0 to 14 pH, 0.1 pH divisions 0 to ±700 mv; d-c; 5 mv divisions 0 to ±1400 mv; d-c; 10 mv divisions	1 scale division

FOR TEMPERATURE MEASUREMENT

Instrument	Type	List No.	Range	Scales
Optical Pyrometer For checking temperatures of molten iron, steel, etc.	Direct-Reading for Molten Metal Temperatures (Non Black-Body conditions — emissivity of 0.4)	8623	1400 to 3200 F	Two: 1400 to 2250 F 1950 to 3200 F
Optical Pyrometer For checking temperatures of flue linings, roof linings, etc.	Direct-Reading for Black-Body conditions.	8621	1400 to 3200 F	Two: 1400 to 2250 F 1950 to 3200 F

LEEDS NORTHRUP
instruments *automatic controls • furnaces*

Journal Ad. No. E-0600(1b)

Metal Progress is published and copyrighted, 1953, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

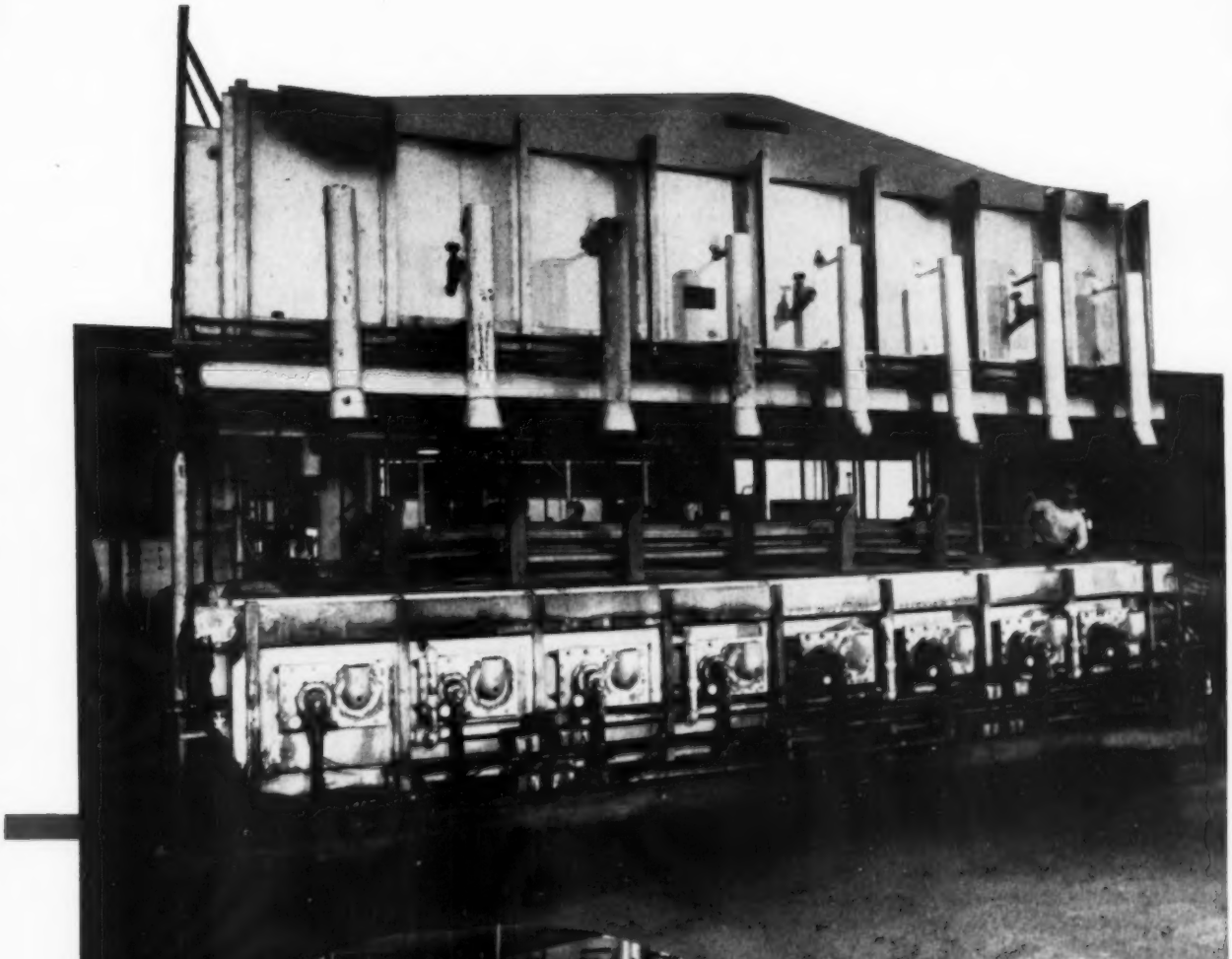
"Investigated all types, Bought Westinghouse"

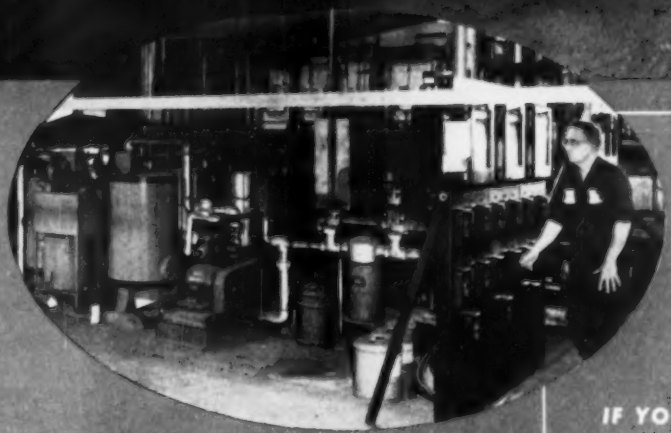
...says Leading Tool Steel Producer

"Our Westinghouse gas-fired rectangular bell furnace has greatly increased our production of high-quality steel. It enables us to meet stringent customer decarburization specifications. Rejects have been virtually eliminated. Several costly production operations have been reduced or are entirely avoided"... reports this leading producer of tool and specialty steels.

"We investigated all types before purchasing this furnace. In our opinion, Westinghouse was the best engineered, and offered the most atmospheric control on the market. To meet the demands for more production, we have just purchased another Westinghouse furnace."

Gas-fired or electric, there's a Westinghouse furnace to meet your heat-treating need. For tool-room application or continuous-line, high production, it's your assurance of an unbiased answer to your all-important problem. Get the facts from your Westinghouse representative. Write today for new 40-page book, B-5459, "Harnessing Heat." Westinghouse Electric Corporation, Industrial Heating Department, Meadville, Pa. J-10377





This three-zone heat control, used with the furnace above, produces more even annealing of her stock, increases production, reduces unit cost.

IF YOUR PRODUCT CALLS FOR HEAT-TREATING...IT CALLS FOR A WESTINGHOUSE FURNACE ...GAS OR ELECTRIC

Service . . . where and when you want it

PROMPT, experienced service is one of the most important plus values you get when you buy Honeywell instruments. An unequalled organization of trained specialists is always at your call at more than 110 offices in the United States and Canada. Offices are located in practically every large industrial city of the country . . . close to every major production center.

Trained Personnel

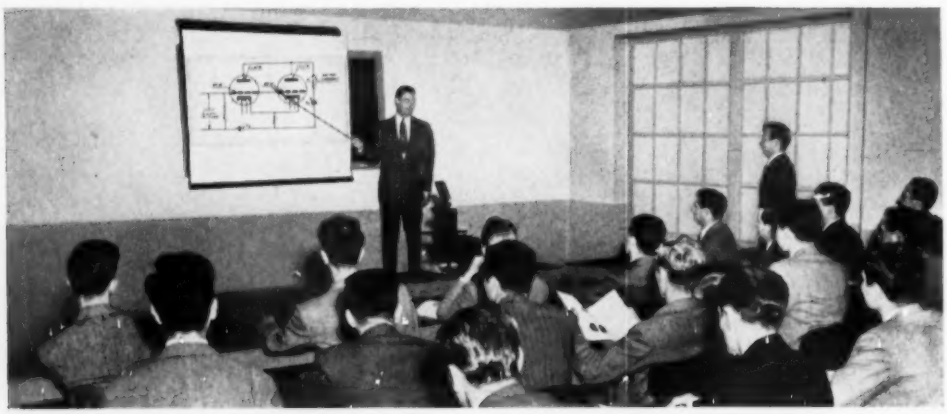
Honeywell service men are schooled not only in the theory of measurement and control, but also in the practical art of keeping good instruments in the best condition. Hand picked men begin this instrument education in an intensive training program in Honeywell factories. After graduation, they serve an apprenticeship in the field offices . . . while they learn still more about instrument maintenance from first-hand contact with plant problems. By the time a Honeywell man arrives at your plant on a call, he's a finished product worthy of the responsibility he bears, and capable of doing the kind of service job that you need . . . and that your Honeywell instruments deserve.

When trouble strikes, a wire or telephone call will bring a service man to your plant . . . often within a few hours. This assurance of prompt action means a lot to your production schedules. You'll never be left out on a limb because of delays in instrument maintenance.

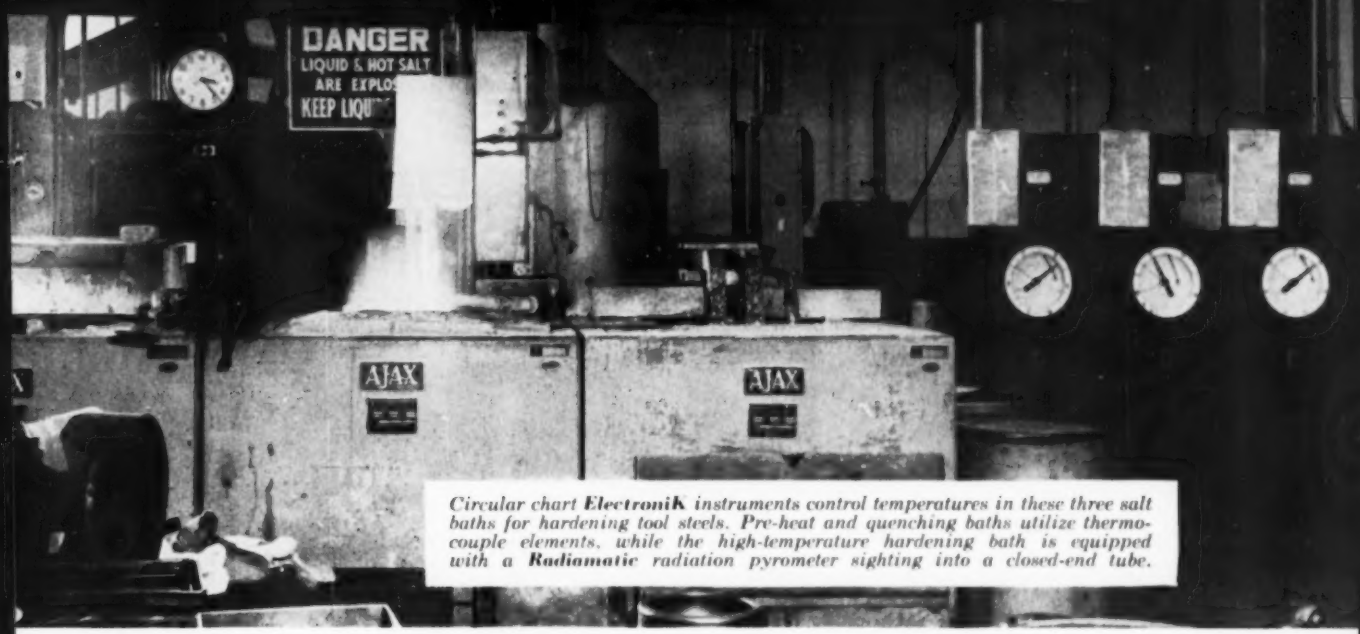
Periodic Service Plan

But why wait for emergencies? Preventive medicine works on instruments, too. And the prescription is simple . . . a Periodic Service Contract, which brings a Honeywell service man to your plant at regular intervals to inspect, clean and adjust any Honeywell instruments you have. The plan is economical . . . can save you many hours of lost production time. Your nearest Honeywell office will be glad to give you full details.

Teamed for Ajax salt baths



TRAINED TO SERVE: *In Honeywell's service school, students get a thorough grounding in instrument theory and practice. After graduation, they become part of the most extensive organization of its kind in the world . . . ready to serve you competently and promptly, whenever and wherever you need them.*



Circular chart ***ElectroniK*** *instruments control temperatures in these three salt baths for hardening tool steels. Pre-heat and quenching baths utilize thermocouple elements, while the high-temperature hardening bath is equipped with a* ***Radiamatic*** *radiation pyrometer sighting into a closed-end tube.*

improved hardening at SKF . . .
with ElectroniK control

HIGH ALLOY TOOLS and parts get the accurate hardening treatment they require, at SKF Industries' Philadelphia plant. Here a battery of Ajax electric salt baths, equipped with *ElectroniK* temperature control, gives heat-treaters everything they need for accurate, high-production hardening.

The battery of furnaces has three separate baths . . . pre-heating, hardening and quenching. Each of these is controlled by its own *ElectroniK* pyrometer, through a sensitive, fast-acting on-off control system. On batch after batch, temperatures stay right "on the line," with a precision that pays dividends in consistent hardness of finished work . . . low distortion . . . freedom from coarse grain structure, brittleness and cracking.

Whatever your own heat-treating job may be, Honeywell controls can help you do it better. Literally thousands of them are at work today on all types and sizes of furnaces . . . handling the most exacting assignments with unmatched accuracy, sensitivity and lasting dependability.

Our local engineering representative will gladly discuss how these advanced controls can help in your heat-treat. Call him today . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Penna.

• **REFERENCE DATA:** Write for new Catalog 1530, "*ElectroniK* Controllers."

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

LINDBERG'S NEW WEST

Lindberg Engineering Company's Los Angeles Plant at Downey, California, has been constructed on four and one-half acres. This new West Coast manufacturing plant is a major step in Lindberg's Expansion Program to keep up with the demand for Lindberg Products.

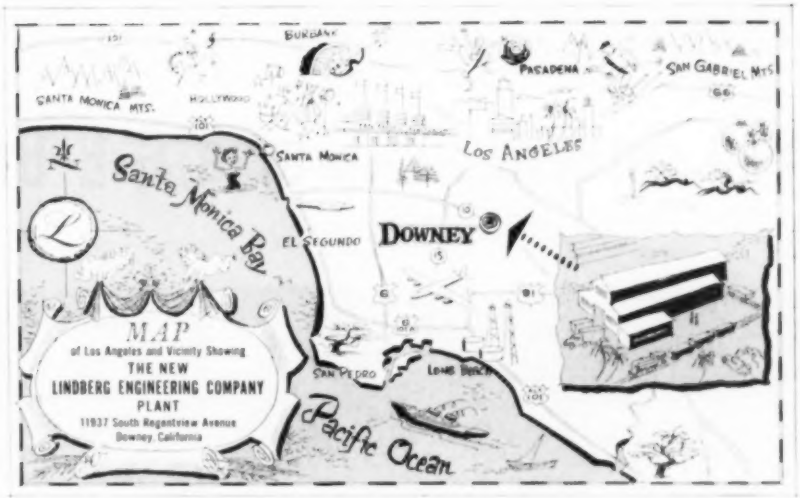
These new facilities, established to service aircraft and other vital West Coast Industries, will speed deliveries, and also offer F.O.B. California prices on the complete line of Lindberg Products. Lindberg has established its position as leader in the field of "Heat for Industry" — no other organization in the world covers the field so completely.

Grand opening of the Lindberg Los Angeles Plant is scheduled for March 25 (week of the Western Metal Show).

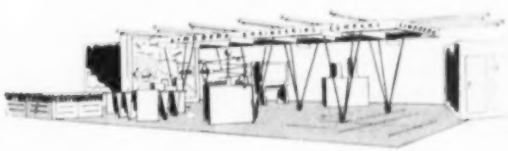
A visit to the plant will provide a diversion in your spare time away from the show. Drop in and see us — we'll be glad to show you around.

LINDBERG ENGINEERING COMPANY, 2448 West Hubbard Street, Chicago 12, Illinois

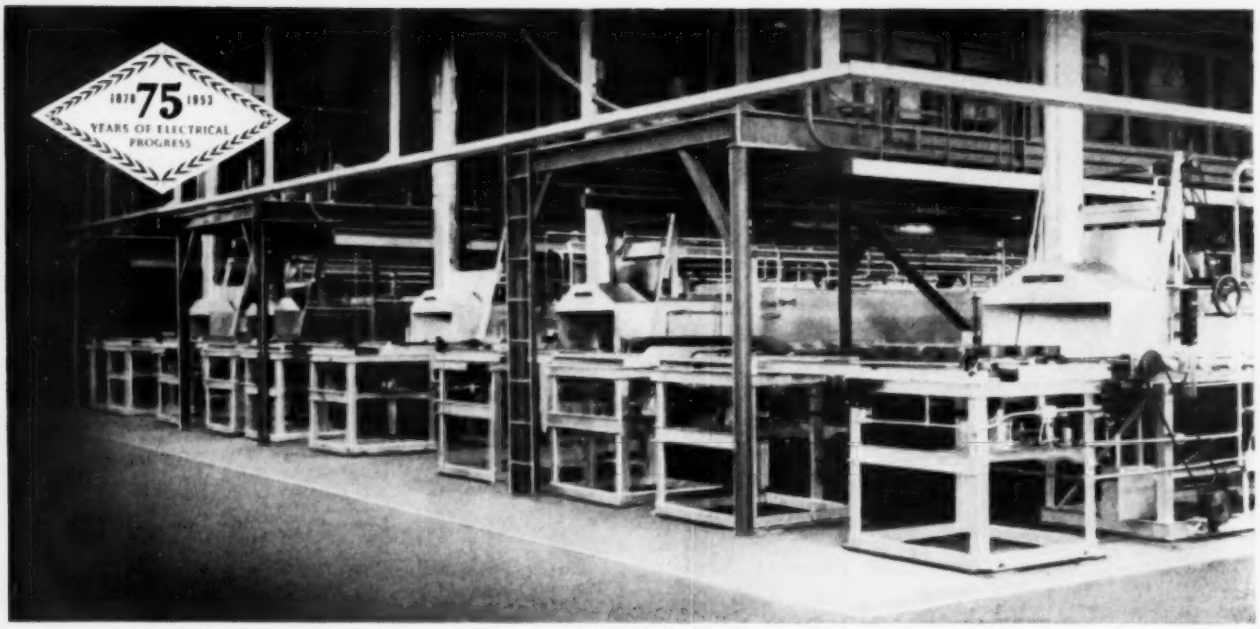
COAST PLANT



Also, you are cordially invited to visit the Lindberg Exhibit (Booth 440) at the Western Metal Exposition, to be held March 23-27 at Pan Pacific Auditorium, Los Angeles.

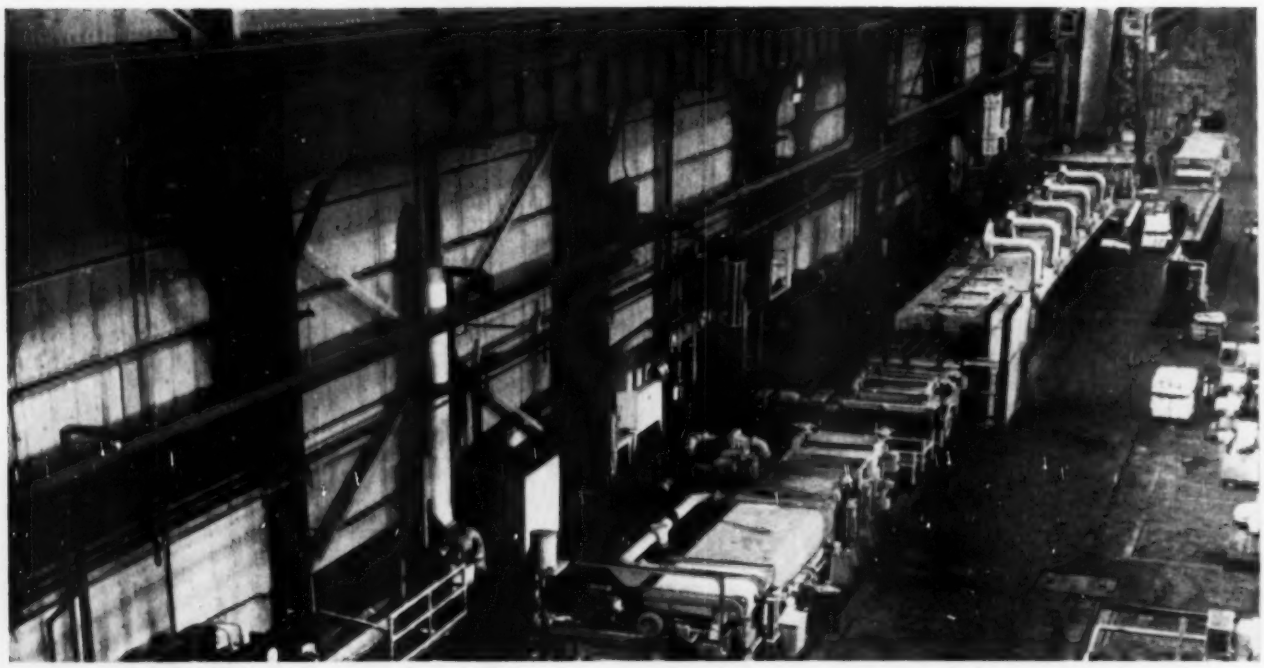


LINDBERG FURNACES

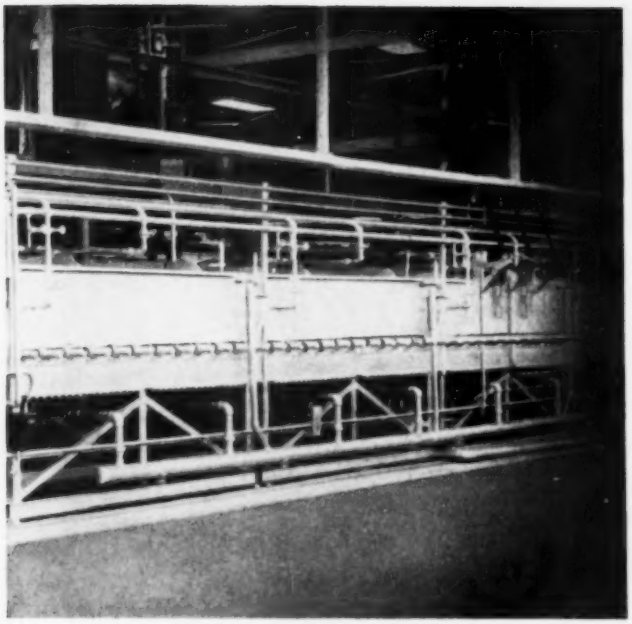


THE EXACT EQUIPMENT to fill your requirements can usually be built from existing G-E designs. Like these five standard roller-hearth annealing furnaces, your equipment can be shipped quicker and will cost you less. G-E Heating Specialists, located in major cities throughout the country, have wide knowledge of your heating

Why You Should Ask For a G-E Bid



CORRECT INSTALLATION is an accepted fact when you specify G-E equipment and supervision. This electric furnace and induction preheat section were designed to meet customer's exact requirements for continuous annealing and galvanizing of steel strip. Experienced installation men supervised the complete set-up.



processes and can assist you in selecting the proper furnace or induction heater. Let him help you to solve *your* problem, as he did for this plant . . .

THE PROBLEM: To sinter carbides at 3000F, in a neutral atmosphere, with temperature variation of ±0.1%. *Standard* G-E equipment fit each requirement.

On Furnaces and Induction Heaters

FAST SERVICE WORK? During World War II, six huge elevator furnaces annealed aluminum at a southern plant. When their Chicago plant opened, the Chicago G-E Service Shop quickly dismantled and transported these furnaces to the new plant, then rebuilt and erected them as bell-type furnaces. The shop nearest you is just as willing to do the large or small repairs you may need—and their phone is answered at any hour.

THE RESEARCH DISCOVERIES and engineering advances in heat-treating made by G-E laboratories are passed on to you as better equipment, and as invaluable process information. From General Electric has come such developments as furnace brazing, the first resistance-electric furnace, stepless temperature control for electric furnaces, the first protective gas-atmosphere producer plus pioneering work on electronic induction heating. We shall continue to earn your respect and business by providing the highest quality equipment and the most advanced designs to fit your exact needs.

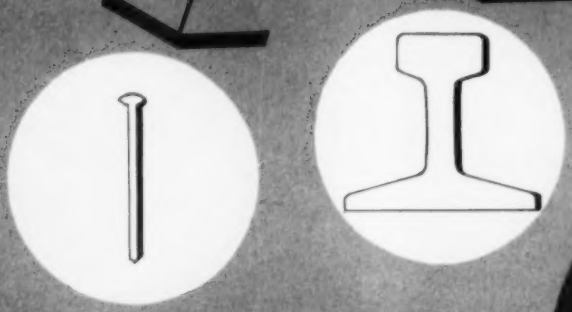
WHEN YOU DEAL WITH G-E on heating equipment, here is what you receive: (1) proper equipment from hundreds of existing designs—or we will build special equipment to suit your needs (2) correct installation supervised by experienced men (3) experienced application men to help solve your heating process problems (4) fast repair work from nearby G-E Service Shops (5) plus development leadership on products and processes. Consider G-E equipment for these heating processes: brazing, sintering, porcelain-enameling, wire-enameling, general heat-treating, and annealing malleable iron.

ASK FOR THE SERVICES of a G-E Heating Specialist when you have heating problems or are considering new heating equipment—call the nearby G-E Sales Office, or write General Electric Company, Schenectady 5, N. Y. Consider well his proposal for it is no idle boast when we say of G-E furnaces and induction heaters . . . 720-100

You can put your confidence in—

GENERAL ELECTRIC

FROM SURGICAL NAILS TO STEEL RAILS



you can test practically anything with a

RIEHLE UNIVERSAL TESTING MACHINE

Compression test in progress on Riehle 60,000 lb. Hydraulic Universal. Photo courtesy of Bundy Tubing Company, Detroit.

When you install a Riehle Pendomatic Universal Testing Machine, it's just like having 5 testing machines at your disposal. That's because every Riehle Pendomatic Universal has 5 scale ranges as standard equipment. All you do is turn the selector knob to the proper range, then conduct the test. No accessories are needed. Guaranteed accuracy is within ½ of 1%.

On the same Riehle machine, you can test specimens with relatively low rupture points, or high yield point specimens. Only Riehle builds testing machines with 5 scale ranges, and only with a Riehle Pendomatic do you get complete coverage of the machine's full capacity.

HYDRAULIC OR SCREW POWER?

What type of loading unit is best for testing machines? Our engineers will be glad to make recommendations for your specific requirements. We build both hydraulic and screw power machines in all sizes up through 400,000 lbs. capacity. Ask your Riehle representative or write our factory for illustrated catalogs.

RIEHLE TESTING MACHINES

Division of AMERICAN MACHINE AND METALS, INC.
EAST MOLINE, ILLINOIS

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

Roughness Comparison Specimens

A new line of roughness comparison specimens has been announced by Acme Industrial Co. The new standards consist of various surface specimens individually finished to definite

micro-inch readings and grouped together in handy comparison bars. The operator merely holds the specimen bar opposite his work to make a visual comparison check of surface roughness, waviness and lay.

For further information circle No. 611 on literature request card on p. 32B

Welding Electrode

A new tungsten-zirconium alloy arc welding rod for inert gas welding jobs has been announced by Sylvania Electric Products Inc. Called Zirtung, the new electrode is the closest commercial approach yet made to a nonconsumable electrode, according to Sylvania engineers. Tests showed only 1 in. of rod consumed in a 12,000-in. semi-automatic welding job on two sheets of 0.035-in. stainless steel. The slight contaminant pick-up and nonwavering arc make it well suited for use on all metals, particularly mild steel, aluminum and magnesium, where contamination on touch starting is greatest. The new electrode operates on the same current range as thoriated tungsten and contains no radioactive materials.

For further information circle No. 612 on literature request card on p. 32B

Foundry Sand Additive

A new resin which eliminates clay balls from foundry sand and makes possible the production of truer, cleaner, more economical castings has been announced by Monsanto Chemical Co.'s Plastics Div. The new material, Lustrex 886, improves sand workability, flowability and packability. This permits uniform packing which eliminates most cracks, fissures and soft spots characterizing untreated sands. One pound of the new material produces uniform clay distribution in one ton of foundry sand. However, only about one-sixteenth of the resin is burned out each time the sand is used. This means that only ¹⁄₁₆ lb. must be added to a ton of sand each time it is recycled.

For further information circle No. 613 on literature request card on p. 32B

Ferritic Stainless Steel

Development of a ferritic stainless steel for high temperature applications has been announced by Crucible Steel Co. of America. The new steel,

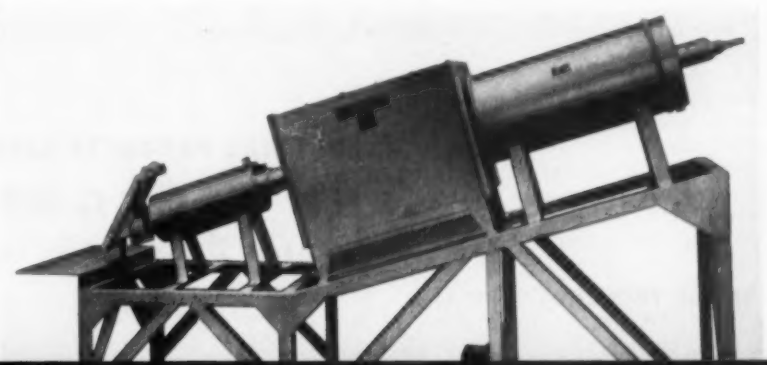
Production of Germanium Metal

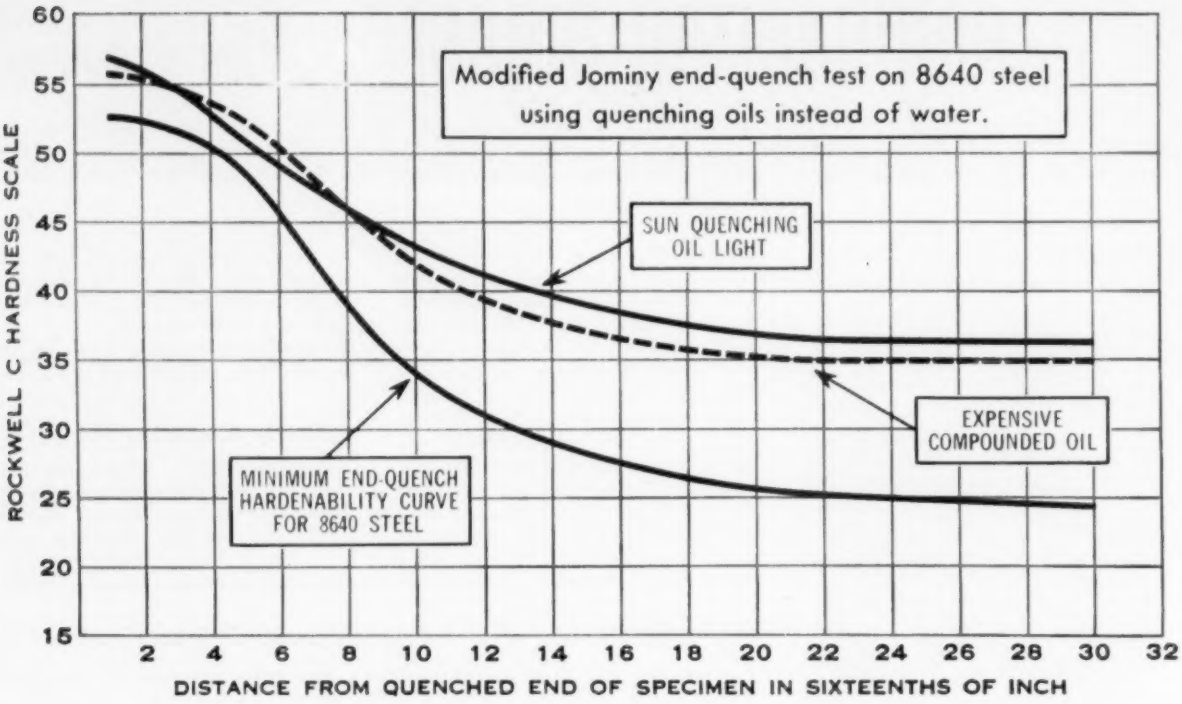
Germanium has recently become of extreme importance in electronics. As more industrial operations are controlled by electronic equipment, there will be a need for expanding germanium production. Germanium oxide ore, a by-product obtained from either zinc or lead smelting, is processed in small quantities to obtain the metal. The electric furnace used in the production operation is a three-section type, inclined for ease of operation. A 6-ft. quartz tube extends through the water-cooled section at the lower end of the unit up through the high temperature section and into the lower temperature first stage furnace. As shown in the illustration, the quartz tube reduces at the upper end where the hydrogen atmosphere is admitted. A small hydrogen flame at the lower door opening indicates rate of hydrogen flow and presence of a pure atmosphere in the tube.

The operation of this furnace, built by Hevi Duty Electric Co., is relatively simple. The operator places the light fluffy germanium oxide powder in small boats or trays. These boats are then pushed up the inclined quartz tube into the first stage furnace. There the oxide is heated to 1200° F. in a hydrogen atmosphere to reduce it to the relatively pure metal. A 4-hr. soak yields 97% pure metal. The temperature of 1200° F. must be accurately controlled because the oxide vaporizes at high temperatures. After the required soak of 4 hr., the boats are pulled into the square second stage furnace operating at 1830° F., where the material fuses. The boats are then pulled into the water-cooled section of the tube where the solid metal is removed.

The next step in the process is a purification operation which is done in an induction furnace with a nitrogen atmosphere. The ingot is drawn through the coils and melted; the impurities are swept to one end of the bar. This end is then sawed off, leaving the pure bar. The pure germanium is cut into 100-g. pieces from which crystals are formed in a crystal growing induction furnace with hydrogen atmosphere. The single crystals are made into transistors; polycrystalline material is used for varistors.— WALTER SCHWARTING

For further information circle No. 614 on literature request card on p. 32B





You can do 95% of all quenching jobs by using SUN QUENCHING OILS

This has been proved again and again in industrial heat treating departments and in the laboratory. The above test curves compare the results obtained from Sun Quenching Oil Light and those from an expensive compounded quenching oil. The hardnesses obtained are far above the commonly accepted minimum.

In addition to assuring consistently uniform physical characteristics, Sun Quenching Oils prevent sludge formation and help remove any deposits that may exist. Oil coolers are kept clean; maintenance costs are decreased. Sun Quenching Oils lower operating costs too. They thin out when heated, drain off parts faster and more completely. Make-up is materially reduced.

For more information about Sun Quenching Oils and how they can help you, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-3.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

SUNOCO®

PHILADELPHIA 3, PA. ◆ SUN OIL COMPANY LTD., TORONTO & MONTREAL

known as Crucible 422, is a modification of the standard Type 420, and has the following nominal composition: 0.20% carbon, 13.00% chromium, 0.70% nickel, 0.30% vanadium, 1.00% tungsten and 1.00% molybdenum. The stress rupture and creep strengths compare favorably with austenitic stainless at 1000° F.

For further information circle No. 615 on literature request card on p. 32B

Flow Meter

Waukee Engineering Co. has announced a new line of flow meters for the indication of flow rates of air and industrial gases. Available in 11 different sizes, each meter has its own built-in calibration for the specific gas and rate of flow to be measured. Measurements are easy to read as the oil in the glass tube not only dampens pulsations but also prevents the accumulation of dirt or foreign matter that might obscure the reading. Each meter has but one moving part, and the cleaning can be accomplished in less than 2 min. without the use of tools. A large tab affixed to the bottom of each meter indicates in large red letters the specific gas being measured. The meters are available for measuring dissociated ammonia, propane, exothermic cracked (rich), exothermic cracked (lean), air, natural gas, ammonia, butane, nitrogen, city gas, purging gas, carrier gas, hydrogen, oxygen and endothermic gas.

For further information circle No. 616 on literature request card on p. 32B

Thermocouple Tube Saves Nickel

A new type of thermocouple-protecting tube has been introduced by Minneapolis-Honeywell's Industrial Division. The new tubes are made of Incoloy, a nickel alloy that has similar physical properties to Inconel, the material used previously, but with only half its nickel content. Incoloy has been approved by the N.P.A. for

use in reducing atmospheres over 900° F. and in neutral or oxidizing atmospheres over 1400° F. Honeywell engineers rate the new alloy at 1900° F., explaining that Incoloy has a chemical composition similar to Chromel T which they had rated at 2000° F.
For further information circle No. 617 on literature request card on p. 32B

New Heliarc Welding Torch

A more efficient and economical Heliarc torch for heavy-duty machine welding has been developed by Linde

Air Products Co. This new HW-13 torch is light in weight and can be mounted on any machine carriage that provides proper speed control for repetitive straight-line, shape, girth seam, or portable welding operations. Water flow keeps the torch cool under the most severe welding conditions. The range of nozzle sizes provides ample gas flow for all operations requiring up to 500 amp. welding current.
For further information circle No. 618 on literature request card on p. 32B

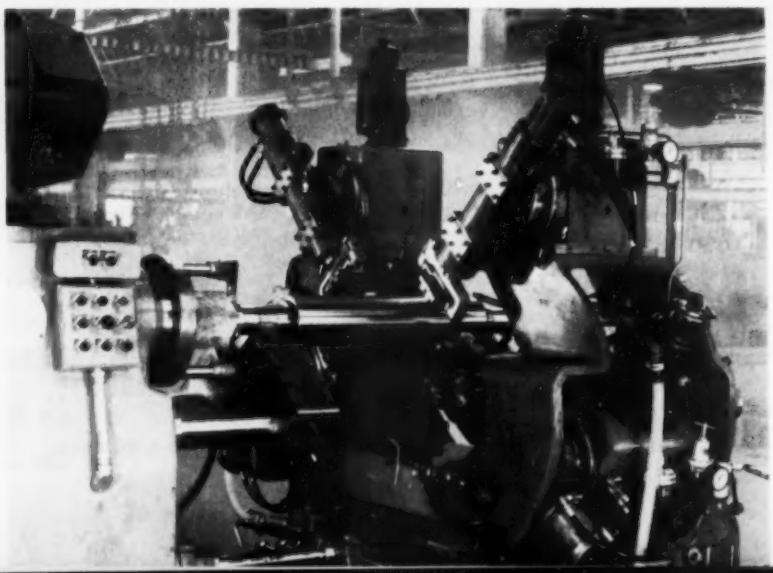
Precision Surface Plates

Surface plates made from a very dense, extremely hard and uniform grained black granite are now avail-

able through Lawley Granite Surface Plate Co. They have a guaranteed surface accuracy up to 0.00005 in. and permit precise measurements in quality control, manufacturing and inspection. The smooth surface per-

Superfinishing of Rolls

A mill which produces stainless steel strip has recently found that one set of superfinished rolls ran 36 machine hours, as against less than 8 hr. for a similar set of ground rolls. In another test it was found that superfinished rolls would handle 280,000 lb. before refinishing, as against less than 100,000 lb. with ground rolls. In a salt spray test there were fewer iron inclusions in the stainless steel strip when the mill roll had been superfinished. The Gisholt equipment on which these rolls were finished operates as follows: The roll is driven with a special adapter, supported with a tailstock, and rests on its own bearings. As the roll is driven, the superfinishing stones contact the work and are oscillated and traversed back and forth over the length of the roll. Three automatic changes of spindle speed give roughing, semifinishing and finishing operations. At the completion of the cycle the roll is wrapped to protect the superfinished surface and is then removed from the machine. The complete operation takes up to 15 min., depending on the size of the roll.
For further information circle No. 619 on literature request card on p. 32B



New facts for your file on U·S·S CARILLOY STEELS

U·S·S Carilloy T-steel has a yield strength of over 90,000 psi., but you can weld it as easily as ordinary carbon steel

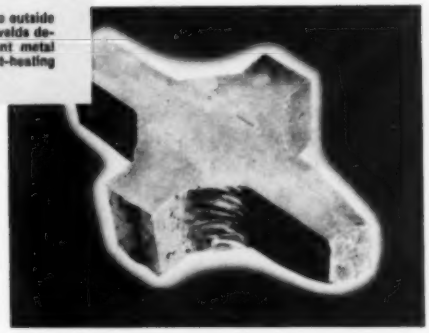
This specimen, flame-cut from 1" Carilloy T-1 plate was chilled to -98°F. and then bent to a full 90° angle. Even though the raw, flame-cut edge made up the outer radius of the bend, there was no sign of failure!

● CARILLOY T-steel is unique. It's a very-high-strength steel that you can weld or flame-cut successfully with ordinary methods used for carbon steel. These operations do *not* lower T-steel's high yield strength. Therefore, you can design to the *full* 90,000 psi. with confidence that parts will retain all of their strength during later fabrication. What's more, T-steel can be readily welded or flame-cut in the field without special pre-heating or stress relieving.

T-steel was designed especially for heavy-duty parts that must operate under rugged service conditions. Despite its high nominal hardness of about 250 Brinell, it has an extremely low transition temperature and remains ductile and tough at the lowest atmospheric temperature. Specimens of T-steel have been flame-cut and then bent to a full 90° angle at -100°F. with no sign of cracking. Other very-high-strength steels would require elaborate and expensive heat-treating to pass such a test.

This remarkable steel is now being used in heavy earth-moving equipment, railroad cars, big water wheel generators, and other equipment that must stand tremendous abuse. In applications where tension is the principal stress, it lets you safely reduce the size and weight of heavily-stressed parts by as much as 50%. Since field welding and flame-cutting are possible, the difficulty and cost of making major repairs is materially reduced.

There are many cases where parts made of T-steel will be less expensive than the steel being used. It will pay you to examine every possible use for it in your equipment. Our experienced metallurgists can give you valuable tips on how and where to use it to best advantage. Just write to United States Steel, Room 2809-L, 525 William Penn Place, Pittsburgh 30, Pennsylvania.



These welded pieces of T-steel broke outside the welds during tensile tests. The welds develop the full strength of the parent metal without special pre-heating or post-heating treatments.

MECHANICAL PROPERTIES OF U·S·S CARILLOY T-1 STEEL

Thickness	¼" to 2" incl.	Over 2" to 4" incl.	Over 4" to 6" incl.
Yield Strength .2% Offset (min)	100,000 psi	90,000 psi	90,000 psi
Tensile Strength (min)	115,000 psi	105,000 psi	105,000 psi
Elongation in 2", % (min)	18	17	16
Reduction of Area, % (min)	55	50	45
Thickness	**¼" to ½" incl.**	**Over ½" to 1" incl.**	**Over 1" to 2" incl.**
Cold Bend	180° D = 1t	180° D = 2t	180° D = 3t

(Testing in accord with A.S.T.M. recommended practices)

Here's where CARILLOY T-STEEL is now being used

- Tension Rods
- Highly-stressed shovel parts
- Ore-car bottoms
- Pole-end pieces for electrical generators
- Liners for heavy truck bodies
- Dredge buckets
- Wind Tunnel flex plates
- Hammer tie plates
- Bridge thrust plates
- Water wheel generator parts
- Butterfly valve liner plates

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS COAST TO COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

"After 17 years,

UNITED STATES STEEL

tough jobs like this become easy"

—says Jimmy Fenchak, U·S·STEEL PRESSMAN

● Jimmy has worked in our Homestead Forgings Division for 17 years—as crane floorman, press helper, craneman, press driver and manipulator operator.

Under his skillful care, the raw ingot gets its first and perhaps most important handling. Jimmy has to coordinate two cranes, a manipulator and the press itself to squeeze the rough ingot into a dense, tough piece of steel—accurately shaped to close dimensions.

That piece in the photo is a good example. It's going to be the main cylinder in an unusually large press of radical design. The press itself will be used for the relatively new method of cold-forming sheet metal over rubber dies.

But the most unusual feature of this forging is the fact that, after it is forged to size, we *squash* it into an oval shape. This shape is required because of unusual stress concentrations in the walls of the press cylinder. The cylinder forging, when completed, will be 14 feet long, 7 feet in diameter, 13 inches thick. It weighs 250,000 lbs.

The Pressman is all-important in a tricky job like this. The hole must be absolutely centered. The entire forging must be sound and free from flaws. And when the time comes to actually apply the big squeeze to form the oval, everything must be synchronized: ingot temperature, ingot position and the amount of pressure exerted by the press.

Fortunately, tough jobs like this are old stuff to U. S. Steel Pressmen like Jimmy Fenchak. Everybody in the crew knows that the job will come off without a hitch.

Our point is this: when you want a truly *quality* forging, you'll be wise to put the job in the hands of men like Jimmy. His skill, combined with the finest steel and machinery, is your best assurance of quality when you buy from United States Steel. For more information on U·S·S Quality Forgings, write to United States Steel, 525 William Penn Place, Room 2809-L, Pittsburgh 30, Pa.

USS

Quality FORGINGS

- heavy machinery parts—carbon, alloy, stainless
- electrical and water wheel shafts
- hammer bases and columns
- marine forgings

New facts for your file on

U·S·S CARILLOY STEELS

Press manufacturer saves money on tools and gets better finished machining with pre-hardened, free-cutting Carilloy FC steel

● Verson Allsteel Press Co., of Chicago, now makes the dies for big press brakes from U·S·S CARILLOY FC steel instead of an ordinary die steel. Pre-hardened, free-cutting FC steel enables this important manufacturer to make harder, smoother dies that are easier to produce.

Here's what Verson says about the performance of FC steel: "This steel cuts much cleaner and more easily than the steel we had been using. As a result, our cutting tools last much longer and the dies are not damaged during machining—even though we are using a much harder steel (300 BHN instead of 250 BHN). In addition, we put a smoother finish on the dies.

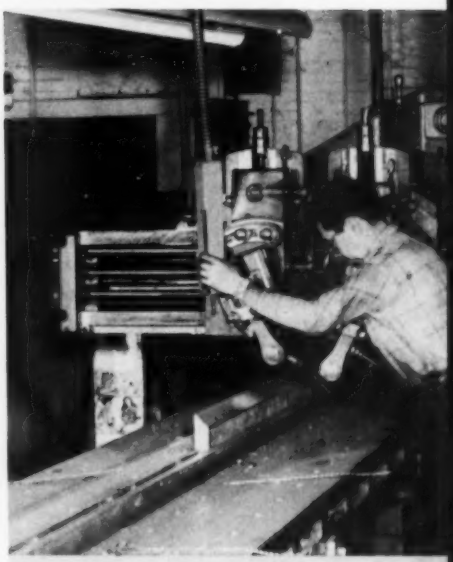
"Smooth finish is especially important in press brake dies, because metal is literally dragged over the die during forming. With these smoother dies, less pressure is needed to make a bend and the dies do not scratch the metal.

"Since the dies are harder, they work better on high tensile steels . . . often eliminate the need for re-treating the dies after use. We're well satisfied with FC steel."

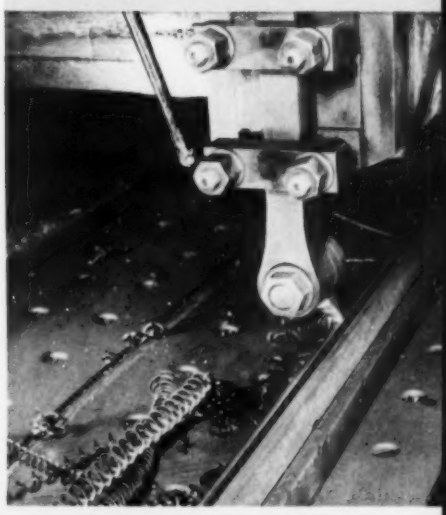
CARILLOY FC is ready for use when delivered.

U·S·S CARILLOY FC steel comes to you already quenched and tempered to the hardness you require and doesn't require heat treatment after machining. It comes in all standard bar forms and sizes in a hardness range from 255 to 375 Brinell. Tensile strengths ranging from 125,000 to 175,000 psi. are available.

Our experienced metallurgists will be glad to discuss the possible applications of pre-hardened, free-cutting FC steel in your products. Just write to United States Steel, Room 2809-L, 525 William Penn Place, Pittsburgh 30, Pennsylvania.



Planing press brake dies from free-cutting Carilloy FC steel at Verson Allsteel Press Co. Carilloy FC is much easier to machine than the steel previously used, so tools last much longer. In addition, better machinability makes it possible for Verson to get a smoother finish and to use a harder steel for the dies. As a result the dies give better service.



Possible Applications for U·S·S CARILLOY FC steel

Arbors
Armature Shafts
Axles
Ball Bearings
Ball Races
Brake Press Dies
Blanking Dies
Bolts
Boring Bars
Bucket Teeth
Bushings
Cams
Chain Links
Chain Pins
Chuck Bodies
Chisels
Chisel Bushings
Clash Gears
Clutches
Collets
Connecting Rods
Connecting Rod Bolts
Coining Dies
Crankshafts
Cutter Bodies
Cylinder Head Studs
Dies
Die Bodies
Drift Pins
Drill Shanks
Elevating Screws
Embossing Dies
Expanding Mandrels
Feed Screws
Forge Hammers
Forge Rams
Forming Dies
Forming Rolls
Gauges
Gears
Guide Pins
Hammers
High Tempered Bolts
Hydraulic Rams
Jigs
Keys
Knuckle Pins
Knuckle Shafts
Lead Screws
Mandrels
Master Hubs
Molds
Nuts
Pinch Bars
Pinions
Pins
Pipe Cutter Wheels
Piston Rods
Pitman Screws
Plastic Molds
Pliers
Power Drive Bits
Propeller Shafts
Punches
Races
Racks
Ratchets
Reamer Bodies
Reamer Shanks
Rollers
Screws
Screw Drivers
Shafts
Shear Blades
Sleeves
Sleeve Shafts
Spindles
Spline Shafts
Spring Collets
Straightening Rolls
Studs
Swaging Rolls
Tap Shanks
Tool Bodies
Tool Post Screws
Trimming Dies
"U" Bolts
Universal Joints
Valve Studs
Worms
Wrenches

USS

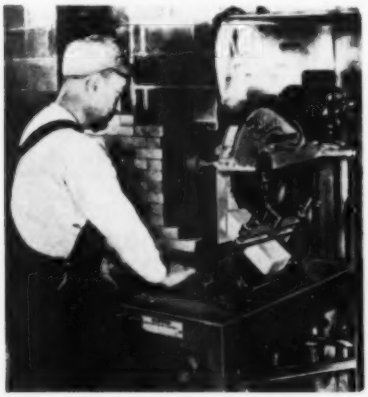
UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST TO COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

mits easy movement of instruments; nonglare finish prevents reflections.
For further information circle No. 620 on literature request card on p. 32B

Masonry Saw Cuts Refractory Shapes

Costly down-time is reduced and longer lasting linings are obtained by using a "Dustless" Clipper masonry



saw to cut special shapes from standard refractory stocks. Any of the difficult or intricate shapes — end skews, keys, splits, soaps, wedges — needed for furnaces can be cut with this saw. Straight, smooth cuts eliminate hidden fractures and give close fitting bricks that reduce the danger of breakouts and require a minimum of mortar. The saw can be operated at the job, even inside the furnace.
For further information circle No. 621 on literature request card on p. 32B

Pyrometer for Induction Heating

A new radiation pyrometer for use in induction heating has been developed by Leeds & Northrup Co. The

new Rayotube can measure temperatures from 800° F. up. Mounted 4 in. from the induction coil it can focus on an opening as small as 0.1 in. between turns of the coil and through this opening it sights on the hot surface of the work. Its housing can withstand surrounding air temperatures up to 350° F. When suddenly exposed to radiation of a workpiece, the Rayotube will indicate 99% of true temperature within 0.6 sec. If temperature of the work is changing, the temperature indicated by the Rayotube detector lags only 0.15 sec. behind that of the work. Its optical system is hermetically sealed against dirt, dust and corrosive fumes. When desired this instrument can also automatically control temperature by turning off current when temperature reaches a predetermined point or by positioning a rheostat to control power output of a generator or the speed of a moving conveyer carrying parts through the inductor.
For further information circle No. 622 on literature request card on p. 32B

Finishing Zinc and Aluminum Die Castings

The Hanson-Van Winkle-Munning Co. has announced a new series of aluminum oxide compositions for the coloring operation in finishing zinc-base and aluminum die castings. Lab-

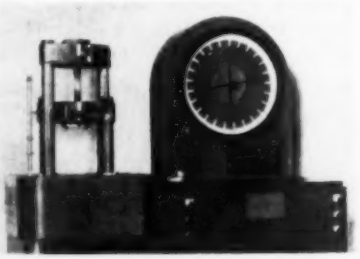
oratory tests and field data indicate that these compositions give the desired luster or color faster than was possible before with compositions of the same grade of fineness. The new compositions may also be used in finishing steel and stainless steel.
For further information circle No. 623 on literature request card on p. 32B

High-Density Metal

The Metal Carbides Corp. is marketing a new metal of high density. Chiefly tungsten, it has a specific gravity in excess of 17.5 g. per cu.cm., which is about 50% greater than lead. This new metal is being used to resist the penetration of radioactive rays and for static and dynamic balancing, as well as other applications requiring maximum weight in minimum space.
For further information circle No. 624 on literature request card on p. 32B

Testing Machines

New models of Baldwin 60-H and 12-H testing machines are announced by Baldwin-Lima-Hamilton Corp. Three changes in these testing machines are most conspicuous. First, clear space between columns has been increased from 10 to 15 in. Second, without losing the advantages inherent in a two-unit design, the machine has been built as a single unit. Separate framework for the gage panel prevents the shock of breaking speci-



mens from being transmitted to the load indicator. Third, both machines are now available with either of two types of indicators: one with two precision Emery 16-in. diameter indicator dials, and the other with the more accurate Tate Emery indicator with three ranges on a single 24-in. dial.
For further information circle No. 625 on literature request card on p. 32B

X-Ray Diffraction Unit

A compact, new X-ray diffraction unit, the XRD-4, was recently announced by the X-Ray Dept., General Electric Co. The unit, designed for film techniques only, requires about

half the floor space taken by the all-purpose unit. The unit has a self-contained water cooler which eliminates plumbing and obviates condensation, mineral and sediment deposits and scale obstructions.
For further information circle No. 626 on literature request card on p. 32B

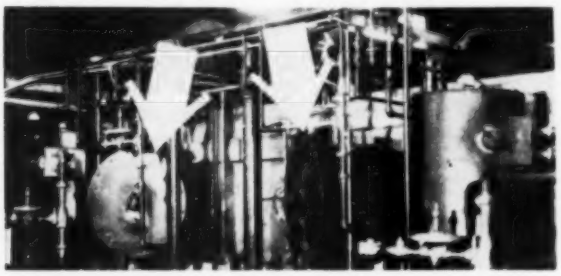
Aluminum Bronze Welding Electrodes

Two new grades of all-purpose aluminum bronze welding electrodes have been added by Weldwire Co., Inc. Weldbest Albronze 100 and 250 are capable of depositing weld metal having a Brinell hardness of 100 and

250, respectively, and are available also as layer-level-wound wire for inert-gas metal-arc welding.
For further information circle No. 627 on card, p. 32B

Hot Atmosphere System for Furnace

The Lithium Co. has developed a hot atmosphere system for application to any indirect-fired furnace now being used without protective atmosphere. A recent installation has been made in the conversion of a continuous roller hearth furnace for annealing welded stainless steel tubing. Previous practice had been to anneal the tubes in a gas-fired, radiant tube, continuous furnace. Despite this provision for indirect heating to avoid contamination by the products of combustion, oxide formation on the tube surface required costly pickling and cleaning after each an-



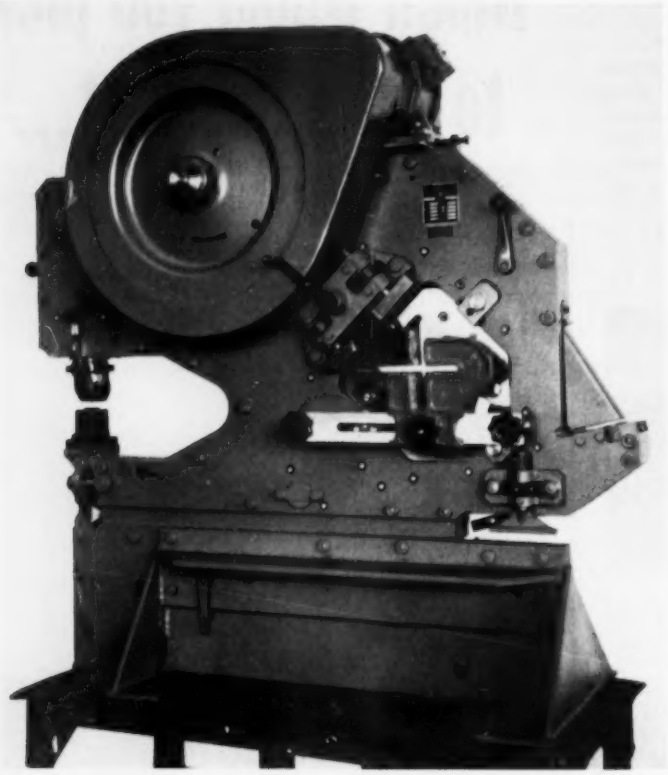
neal. The installation of lithium vaporizers in conjunction with standard exothermic gas cracking chambers, attached to the furnace, provided the means for protecting the surface of the work and for adding heat to the furnace. The lithium vapor, produced by heating the lithium compound in the vaporizer, mixes with the products of combustion gases resulting from the heating. This hot mixture together with the hot exothermic atmosphere from the gas cracker provides the necessary surface protection.
For further information circle No. 628 on card, p. 32B

Shell-Molding Binder and Parting Agent

A four-in-one "foundry package" of all synthetic materials required for the new shell molding process and for traditional sand casting is now available from the General Electric Co.'s Chemical Div. Included are two materials essential to shell molding—S-1054, a new phenolic resin binder, and SM-55 silicone parting agent to release shell molds from their metal patterns—together with G-E 12353 liquid core-binder resin and G-E 3255 Permafil for im-

pregnating porous castings. S-1054, a new two-stage powdered phenolic resin, starts melting slowly when the sand-resin mix is dropped on the pattern and therefore makes possible denser packing, particularly in deep draws, slots, holes and other intricate areas. SM-55 is a water emulsion silicone parting agent which leaves negligible residue on patterns and has release properties that permit the use of smaller amounts of silicone.
For further information circle No. 629 on card, p. 32B

One Unit to Cut, Punch, Cope and Shear . . . .



The famous

PEDDINGHAUS

Universal

STEEL WORKERS

This PEDDINGHAUS Universal Steel Worker combines in one rugged unit a punch, bar, angle and tee-cutter, coper and plate shear. The punching machine has an automatic spotting lever for accurate punching. Both hands of the operator remain free to hold the material.

The Automatic Bar, Angle and Tee-Cutter is always ready to produce *clean* cuts, square or on bevel. The Coper is equipped with rectangular knives for square coping or triangular notching on all sections.

The Plate Shears cut plates of unlimited length or width. The forged steel downholder is easily adjustable for different thicknesses of material.

Five sizes are available. Write for illustrated descriptive folder giving complete details, capacities and specifications.

Deliveries from stock.

The famous Peddinghaus

HIGHER SPEED BILLET SHEARS CUT COSTS

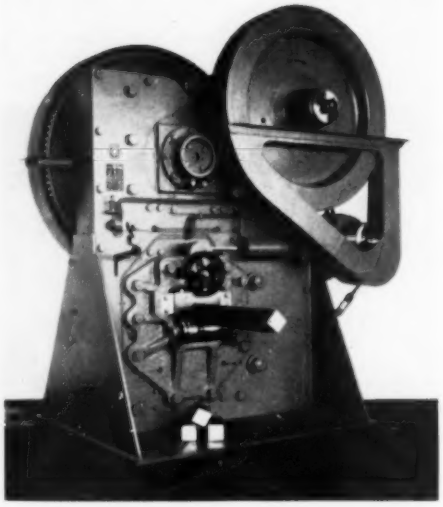
OVER ONE HUNDRED IN SUCCESSFUL 24 HOUR DAILY OPERATION

Over one hundred of these incomparable PEDDINGHAUS billet shears are reducing production costs in continuous use in drop forge shops, automobile plants, and wherever large quantities of billets require shearing.

The automatic releasing gauge has coarse and fine adjustment. It is supported eccentrically so the cut-off piece cannot jam and will drop freely. Hinged to the machine, it can be swung out by loosening two bolts, giving easy access to the knives.

These billet shears are available in capacities for up to 5⅛" squares. Constructed with a one-piece cast steel shear throat unit. They feature smooth running at top capacities with minimum shear stresses and protection against overloads. Write for descriptive literature and complete specifications.

Delivery is guaranteed within two months.



MADDAUS MOELDERS & CO., INC.

15 WILLIAM STREET ***Sole Agents*** **NEW YORK 5, N. Y.**

630. Abrasive Cutting
20-page booklet 6, "Metallic Cutting Off With Abrasive Wheels". *Abrasives Div., Carborundum Co.*

631. Alkaline Derusting
Bulletin on electrolytic process operated at room temperature, for derusting without acid. *Enthone*

632. Alloy Castings
16-page Booklet 112 on alloy castings for furnace uses. Design stresses vs. temperature. *Michiana Products*

633. Alloy Steel
16-page booklet, "Alloy Steels and How to Get the Most Out of Them", contains seven case histories selected from widely varied fields. *Republic Steel*

634. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

635. Alloy Steel
176-page bound book on hardenability, mechanical properties, heat treatment and applications of alloy steels. 28 pages of tables at end. *U. S. Steel*

636. Alloy Steel
Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

637. Alloy Steel
68-page "Aircraft Steels" booklet includes revised military specifications. Also stock list. *Ryerson*

638. Aluminum
20-page bulletin on extruded aluminum, drawn pipe and tube, and coiled aluminum sheet. *Revere*

639. Aluminum Alloys
36-page book on analysis of aluminum, brass, bronze alloy specifications. *Sonken-Galamba Corp.*

640. Aluminum Bronze
Engineering manual on wrought forms of aluminum bronze. *Mueller Brass*

641. Aluminum Castings
Brochure "How To Cut Die-Casting Finishing Costs" deals with aluminum castings. *Monarch Aluminum*

642. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

643. Aluminum Extrusions
Data on services in the field of aluminum extrusions. *Himmel Bros. Co.*

644. Ammonia Dissociators
Bulletin on dissociating process gives advantages of ammonia as controlled atmosphere. *Sargeant & Wilbur*

645. Annealing
Booklet on burner for annealing and other uses where flame impingement is not permissible. *Bloom Engineering*

646. Annealing Furnaces
8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

647. Arc Welding
Procedure for metal arc welding of copper and copper alloys. *Krembs & Co.*

648. Atmosphere Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Engineering*

649. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

650. Atmosphere Furnace
Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

651. Atmosphere Generators
12-page booklet on gas producers describes equipment and gives data on composition and applications of atmospheres. *Bellevue Industrial Furnace*

653. Automatic Polishing
14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. *Murray-Way*

654. Barrel Finishing
22-page book on single-unit installation to yield savings up to 95% in finishing various parts. *Almco Div.*

655. Barrel Plating
Folder on barrel plating with unique contact arrangement for maximum current distribution. *Daniels*

656. Bending
Catalog on presses for bending, forming, blanking, drawing and multipunching. *Cleveland Crane & Engineering*

657. Beryllium Copper
Helpful engineering information contained in monthly beryllium copper technical bulletins. *Beryllium Corp.*

658. Blackening Compounds
Bulletin on blackening compounds (for ferrous alloys) to AMS Spec. 2485. *Swift Industrial Chemical*

659. Blast Cleaning
24-page Bulletin 400 on blast cleaning installations for large work. *Pangborn*

660. Brazing
Free sample of silver brazing-alloy preformed washer coined from wire. *Lucas-Milhaupt Engineering*

661. Brazing
24-page Bulletin 20 on advantages of Easy-Flo silver brazing alloy, with information about joint design and fast production methods. *Handy & Harman*

662. Brazing
Bulletin 124 — on salt bath brazing process — shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajax Electric*

652. Brass Rod Handbook

At least 75% of all copper alloy rod is free-cutting brass. This large industrial fact sets the pattern for the new and authoritative Rod Handbook of the Copper and Brass Research Association.* Emphasis is on machining, with free-cutting brass as the standard to which all other rod alloys are referred. In addition to machinability ratings of the usual type (based on free-cutting brass = 100), 22 alloys are rated for machinability on a tool wear basis, both for carbide-tipped tools and standard high speed steel. Thus, for example, naval brass is given a tool wear rating of 4, which means that, when naval brass is being machined with a carbide tool, the tool may be expected to require dressing about four times as frequently as when the same shape is being machined from free-cutting brass with a carbide tool.

*Copies are available at no charge to readers of Metal Progress who circle No. 652 on the request card, page 32B.

All aspects of machining are dealt with, including the coolant-lubricants. Tool shapes and speeds are given for turning tools, forming tools, milling cutters, boring tools, drills, taps, cut-off tools, chasers and saws. Supplementary or secondary operations, such as knurling, thread rolling and bending, are discussed in relation to how they influence the selection of a copper alloy other than free-cutting brass. The book concludes with a step-by-step procedure and four tables for estimating the quantities of rod required for a given job.

663. Brazing and Annealing
Bulletin on high speed heating equipment for brazing, flame annealing, hardening, selective heating, and heating for forming. *Gas Appliance Service*

664. Bronze
12-page bulletin on properties and uses of continuous cast bronze rod and tube. *American Smelting & Refining*

665. Burners
16-page bulletin on selection of gas burners. *Western Products*

666. Carbide Coatings
12-page Bulletin 8065, "Flame Plating", on method of applying tungsten carbide coatings. Comparative wear test data. Applications. *Linde*

667. Carbide Tools
48-page catalog on carbide tools. *Nelco Tool*

668. Carbon and Graphite
20-page catalog on carbon and graphite uses in metallurgical, chemical and process fields. *National Carbon*

669. Carbonitriding
8-page bulletin on equipment and process for carbonitriding. *Armour*

670. Case Hardening
Bulletin 159 describes standard rated batch furnaces for case hardening. *Surface Combustion*

671. Cast Iron
38-page brochure on gray iron casting procedures and products. *American Car and Foundry*

672. Cast Iron
"Guide to the Selection of Engineering Cast Irons". *International Nickel*

673. Chromate Coatings
Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

674. Chromium Cast Iron
48-page book on effects of chromium on properties of cast iron. Data on production and uses. *Electro Metallurgical*

675. Chromium Plating
"How to Chromium Plate 20 to 80% Faster" describes self-regulating high-speed bath. *United Chromium*

676. Chromium Stainless
12-page book on fabrication and use of Type 430 stainless steel. *Sharon Steel*

677. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

678. Cleaning
Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

679. Cleaning
16-page Bulletin 215 on blast cleaning tables. *Pangborn*

680. Cleaning
20-page book on electrolytic and non-electrolytic cleaning, tumbling, paint stripping. *Magnuson Products*

681. Cleaning
12-page bulletin on washing and drying machines; conveyor, cabinet, drum and vertical types. *Industrial Systems*

682. Cleaning Equipment
Folder on degreaser. Data on different models. *Topper Equipment*

683. Cleaning Equipment and Materials
Series of bulletins on dry cleaning process, degreasers, metal parts washers, degreasing solvents, emulsion and alkaline cleaners and rust-proofing compounds. *Detrex Corp.*

684. CO_2 as Coolant
Bulletin on use of a jet of liquid carbon dioxide directed at point of contact between cutting tool and work to keep both cool. *Pure Carbonic Co.*

685. Coatings, Metal
High-vacuum evaporation of metals set forth in detail in 12-page booklet. *Consolidated Vacuum Corp.*

686. Cold Finished Bars
Engineering bulletin, "New Economies in the Use of Steel Bars". *LaSalle Steel*

687. Cold Heading Brass Wire
"Cold Heading Extruded Brass and Copper Wire" gives physical and fabrication properties, applications, lb. per 1000 ft. and ft. per lb. *Chase Brass*

688. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

689. Controlled Atmospheres
24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Lectrodryer*

690. Controlled Atmospheres
12-page Bulletin 1013 on atmosphere dryers. *Selas*

691. Core Baking
16-page bulletin on electronic equipment for foundry core baking. *Induction Heating Corp.*

692. Corrosion
32-page brochure on causes of corrosion and means of combating them. Choice of materials for condenser tubes. *Revere Copper & Brass*

693. Corrosion Control
6-page article on Nielizing process for producing completely clean, nonactive surface on ferrous metal. *Nielco Labs*

694. Creep of Titanium
Data on creep of commercially pure titanium. *Rem-Cru Titanium*

695. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

696. Cutting Compounds
Data on cutting compounds for stainless and titanium. *Hangsterfer's Labs.*

697. Cutting Machinery
Brochure on high-speed cutting machinery and wheels. *Stone Machinery*

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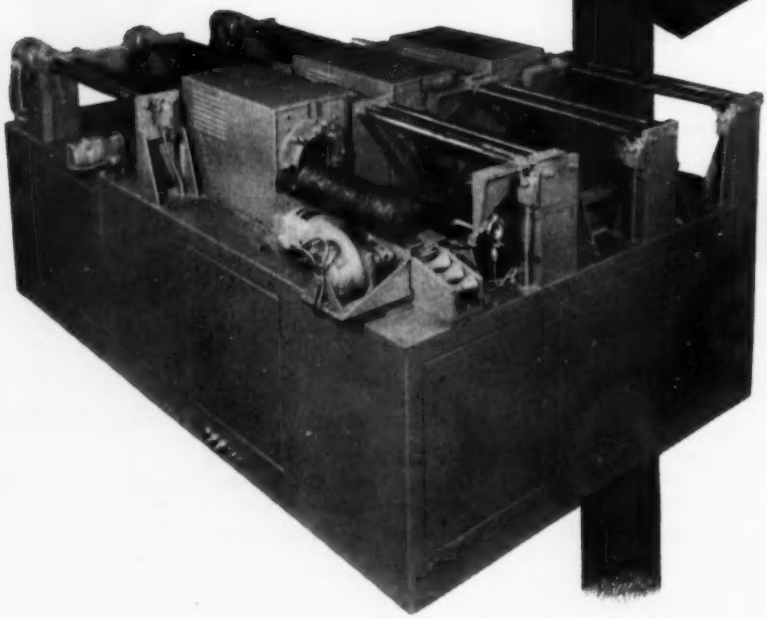

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New pamphlet on sulphurized oil applicable to stainless steel and more easily machined alloys. *Gulf Oil*

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Facts on more efficient and economical plant operation through the use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

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"Pioneering the Deep Drawing of Titanium", by J. Walter Gulliksen. *Worcester Pressed Steel Co.*

701. Degreasing
Pamphlet on properties and use of trichlorethylene. *Niagara Alkali*

702. Degreasing
24-page brochure on medium-pH cleaner to follow solvent degreasing or other precleaner. *Northwest Chemical*

703. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *Du Pont*

704. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

705. Desulphurization
12-page "Desulphurizing Molten Metal With Dense Soda Ash", of special interest to foundrymen. *Solvay Process*

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"Die Steels for Hot Work", helps in selection of best grade for particular jobs. *Vanadium-Alloys Steel*

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12-page Bulletin B100 gives classification and data on buffs for cutting and coloring. *Hanson-VanWinkle-Munning*

708. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

709. Electric Furnaces
Bulletin 473 on automatic melting machine for ferrous and nonferrous alloys. *Detroit Electric Furnace*

710. Electromagnet
Bulletin on multipurpose high-flux-density electromagnet for metal research. *Arthur D. Little, Inc.*

711. Fabrication Data File
Reference file of engineering information about equipment and processes used for stampings, heavy weldments and pressed steel shapes. *Brandt*

712. Fasteners
8-page Bulletin 660 on stainless steel wire thread inserts for tapped holes. Design, maintenance. *Heli-Coil*

713. Fine-Grain Brass
12-page Bulletin B-39 on brass sheet and strip having unusually fine grain size and good finishing properties. *American Brass*

714. Finishing
Book, "Abrasive Grain and Powders for Use in Metal Finishing". *Abrasives Div., Carborundum*

715. Finishing Aluminum
Folder and reprint on an electroless surface conversion process for bonding paint to aluminum and protecting the metal. *American Chemical Paint*

716. Finishing Systems
Bulletin on cleaning and rust-proofing equipment, spray booths and drying ovens. *Peters-Dalton*

717. Flame Hardening
Bulletin 251-B on high-speed burners for flame hardening, annealing, brazing, preheating, descaling and other localized heat treatments. *Selas*

718. Flame Hardening
12-page bulletin on flame-hardening machines for automatic gear hardening, crankshaft hardening and bolt hardening. *Carlingo Commodities Corp.*

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12-page bulletin on location of flaws by two dye-penetrant inspection methods. *Turco Products*

720. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g.*

743. Forgings
20-page Catalog 51 on various types of forgings, their strength and related data. Tables, drawings. *Merrill Bros.*

744. Forgings Design
Design chart gives six design factors versus nine characteristics of drop forgings; methods of attacking part design problems. *Drop Forging Assoc.*

745. Forming Dies
Data on roller dies for forming tubes and rolled shapes. *American Roller Die*

721. Fundamentals of the Process
20-page bulletin on fundamentals of the shell molding process. 13 close-up photos illustrate each step. *Bakelite*

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8-page bulletin on production of stainless and heat resistant shell mold castings from 1 oz. to 350 lb. *Solar Aircraft*

723. Process for Stainless Steel
8-page technical bulletin on application of shell molding to production of stainless steel castings. *Cooper Alloy Foundry*

724. Design Considerations
8-page reprint "Designing for Shell Molded Castings". *Sutter Products*

725. Blending of Sand and Resin
Bulletin 404 on twin-shell equipment for dry blending of sand and shell mold resin. Data on order of charge and mixing time. *Patterson-Kelley*

726. Automatic Mold Making
Bulletin on automatic machines of single or multiple-head types for making shell molds. *Winter Eng'g.*

727. Automatic Mold Making
Bulletin S on shell molding machines with automatic cycle. *Sutter Products*

728. Automatic Mold Making
Bulletin describes machine that performs 10 shell-mold process steps in sequence. *Shellmold & Machine*

729. Resin Binders
8-page bulletin on use of phenolic resins in making of shell molds. *Durez*

730. Resin Binders
Data sheet on synthetic resins for bonding. *Borden Co.*

731. Resin Binders
11-page Bulletin 1503 on use of phenolic resin; 8 illustrations. *Reichhold Chemicals*

732. Resin Binders
8-page Bulletin 222 on use of resins. *Chemical Div., General Electric*

733. Resin Binders
Set of data sheets on six phenolic resins for use in making various types of shells for shell mold casting. *Bakelite*

734. Pick-Up Agent
Data sheet on liquid used as a wetting or pick-up agent which permits adhesion of individual resin particles to the sand grains. *Bakelite*

735. Silicone Release Agent
Data sheet on silicone release agent which enables free removal of molds and cores from pattern plates and boxes. *Bakelite*

736. Silicone Release Agent
Bulletin AD3A on the use of silicones as parting agents for release of the shell mold. *Chemical Div., General Electric*

737. Adhesives for Bonding Shells
Data sheet on adhesives for bonding together the halves of shell molds. *World Bestos*

738. Back-Up Material
Technical Bulletin 5 on use of metal shot as weighting or back-up material in shell molding. Comparative data on four materials. *Harrison Abrasive Div.*

739. Flow Meters
12-page Bulletin 2M50 on mechanical flow meters that give high accuracy at low flows. *Hagan Corp.*

740. Flux, Aluminum Melting
Data sheet on four fluxes for degassing and purifying aluminum alloys. *Atlantic Chemicals & Metals*

741. Forced Convection Furnaces
Bulletin 131 on gas-fired and electric heat treating furnaces with 100% forced convection heating. *Lindberg*

742. Forging Manipulators
Folder on manipulators for automotive, ordnance, aluminum and specialty forging. *Salem-Brosius*

746. Foundry Costs
Engineering and cost analysis of core baking equipment. *Induction Heating*

747. Foundry Practice
Article discusses fume control in brass foundry. *R. Lavin & Sons*

748. Foundry Resin
12-page Bulletin 224 on phenolic resin for use as a core sand binder. Complete data. *Chemical Div., General Electric*

749. Furnace Belts
44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

750. Furnace Construction
12-page bulletin on thin-wall construction for furnace enclosures. Engineering drawings. *Bigelow-Liptak*

751. Furnace Controls
Bulletin on instruments and controls for heat treating furnaces. *Hays Corp.*

752. Furnace Controls
28-page catalog 51-1 on furnace and oven controls lists prices and illustrates variety of instruments such as temperature controllers, recorders, indicators and valves. *Minneapolis-Honeywell*

753. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

754. Furnace Insulation
Bulletin on ceramic fiber that can give impressive savings compared with high-quality insulating brick. *Refractories Div., Carborundum Co.*

755. Furnace Maintenance
16-page "Maintenance Guide for Electric Heat Treating Furnaces" describes preventive program. *Hevi Duty Electric*

756. Furnaces
6-page folder describes 18 typical installations of gas-fired and electric furnaces. Equipment for bright annealing, scale-free hardening, carbon restoration, carburizing and production heat treatment. *Electric Furnace Co.*

757. Furnaces
High temperature furnaces for temperatures up to 2000 F. are described in leaflet. *Carl-Mayer Corp.*

758. Furnaces
40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

759. Furnaces, Heat Treating
Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Engineering*

760. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

761. Furnaces, Heat Treating
Catalog on furnaces for tool room and general-purpose heat treat. *Cooley*

762. Furnaces, Heat Treating
Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

763. Furnaces, Laboratory
26-page "Construction of Laboratory Furnaces" contains many diagrams, charts, tables, and information on how to construct furnaces. *Norton Co.*

764. Furnaces, Rotary Hearth
Folder giving drawings, dimensions, capacity, Btu required for drawing, annealing, forging. *Gas Machinery*

765. Furnaces, Small Tool
Folder describes complete set-up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

766. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

767. Gas Carburizing
Bulletin on gas carburizing in rotary furnaces. *American Gas Furnace*

768. Gas Flow Meter
Bulletin on gas flow meter for furnace installations. *Hays Corp.*

769. Gear Hardening
Folder on application of induction heating to high-production hardening of gears. *Westinghouse*

770. Grinding Fluids
8-page article on water-mix fluids for surface, cylindrical and centerless grinding. *D. A. Stuart*

771. Hardening Control
Bulletin on instrument for controlling flame hardening and other applications. *Carlingo Commodities Corp.*

772. Hardening Stainless
24-page "Story of Malcomizing" describes surface hardening of stainless steels. *Lindberg Steel Treating Co.*

773. Hardness Tester
Bulletin on Impressor portable hardness tester. *Barber-Colman*

774. Hardness Tester
Bulletin on testing by Rockwell method of large or odd-shaped specimens with unique clamping method. *Testing Equipment Co.*

775. Hardness Tester
Circular on portable hardness tester in sizes for work 1 to 6 inches round and flat. *Ames Precision*

776. Heat Processing
Bulletin answers questions: what is to be heated, what sections are to be heated, why the material is to be heated, to what temperature, how long. *Selas*

777. Heat Resisting Alloy
Pyrasteel bulletin describes chromium-nickel-silicon alloy for service economy in resisting oxidation and corrosion to 2000 F. *Chicago Steel Foundry*

778. Heat Resisting Alloy
Bulletin 1052 on properties of Kentanium for 1800 F. *Kennametal, Inc.*

779. Heat Treating
Bulletin, "Make Your Own Gas", describes generator to convert oil to gas for standby or primary fuel. *Vapofier*

780. Heat Treating
Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam*

781. Heat Treating Ammonia
"Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div., Allied Chemical & Dye Corp.*

782. Heat Treating Fixtures
24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

783. Heat Treating Forgings
Article on heat treatment of forgings at Interstate Drop Forge. *Sunbeam*

784. Heat Treating Guide
Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

785. Heaters
20-page bulletin on immersion heater for plating, cleaning, finishing and quenching tanks. 12 case histories. *Kold Hold Mfg.*

786. Heating Method
16-page reprint on uses of immersion gas heating. *Dewey Gas Furnace*

787. High-Temperature Alloy
Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

788. High-Temperature Alloys
"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 super-alloys and lists physical and mechanical properties of two newly developed alloys. *Haynes Stellite*

789. High-Temperature Alloys
High temperature work sheet provides valuable suggestions for solving high temperature problems in design and production. *International Nickel*

790. High-Temperature Belts
24-page bulletin on metal conveyor belts. *Wickwire Spencer*

791. High-Temperature Fans
Bulletin 645 on fans for use at temperatures to 1800° F. *Michiana Products*

792. High-Temperature Steels
87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

793. High-Tensile Steel
Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

794. Hydride Descaling
24-page book "Handling Metallic Sodium" with special reference to sodium hydride descaling. *U. S. Industrial Chemicals*

795. Hole Punching
32-page Catalog BL on equipment for punching mild steel up to ⅛ in. thick. *Wales-Strippit*

796. Hot Work Die Steels
Bulletin on Cr-Mo-V hot work die steel. *Allegheny Ludlum*

797. Identifying Alloys
Booklet of procedures for rapid identification of more than 125 metals and alloys. *International Nickel*

798. Identifying Stainless
Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

799. Induction Heat Control
Data sheet on radiation pyrometer for direct measurement of work being induction heated. *Leeds & Northrup*

800. Induction Heat Control
Sheet 83 on miniature radiation-detecting temperature-measuring device for flame hardening and induction heating. *Minneapolis-Honeywell*

801. Induction Heating
Bulletin on new-design tube for induction and dielectric heating. *Federal Telephone & Radio*

802. Induction Heating
Data folder on megacycle tube-type machines for soldering, brazing, hardening. *Sherman Industrial Electronics*

803. Induction Heating
Bulletin on new 60-cycle induction furnace for heating aluminum, magnesium, copper and brass for forging, extrusion and rolling. *Loftus Engineering*

804. Induction Heating
12-page bulletin 5679 on induction hardening, brazing, annealing at 1000, 3000, and 10,000 cycles. *General Electric*

805. Industrial Finishing
Catalog A-653 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

806. Inert-Arc Welding
Bulletin on material for eliminating porosity problems in inert-arc welding of rimmed steel. *Spekaluminite*

807. Infra-Red Heating
20-page bulletin on infra-red heating for drying, degreasing, dehydrating, preheating and other applications. *Fostoria Pressed Steel*

808. Inspection
8-page bulletin on optical equipment and accessories for inspection. *Arthur S. LaPine & Co.*

809. Instruments
28-page catalog No. 5000 describes instruments, control devices and related components. *Minneapolis-Honeywell*

810. Instruments for Plating
Bulletin 803 on instruments for plating and other finishing operations. *H. O. Trerice Co.*

811. Ion Exchange
Data and specifications on monocolumn demineralizers using ion-exchange method. *Penfield Mfg. Co.*

812. Ion Exchange
28-page book on demineralization, including silica removal by ion exchange. *Permutit*

813. Laboratory Furnace
Bulletin 321 on oven to provide constant weight of air circulation at all temperatures. *Blue M Electric*

814. Laboratory Furnaces
Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

815. Laboratory Furnaces
Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

816. Laboratory Safety
48-page book includes data, techniques and equipment. Useful manual for setting up complete laboratory safety programs. *Fisher Scientific*

817. Lockseam Tubing
Blueprint of size ranges of round or oval lockseam tubing in a wide range of metals. *H & H Tube and Mfg.*

818. Lubricant
Uses of colloidal graphite for hot metalworking operations (deep piercing, forging, stretch forming and wire drawing operations). *Acheson Colloids*

819. Machining Alloy Steels
24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

820. Machining Copper Alloys
32-page booklet gives cutting speeds, feeds, rakes, clearances for more than 40 copper alloys. *American Brass Co.*

821. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

822. Magnesium Melting
Bulletin on use of fabricated steel crucibles in melting of magnesium alloys. *American Tank & Fabricating*

823. Malleable Iron
12-page Bulletin 5797 on electric-furnace annealing of malleable iron. *General Electric*

824. Meehanite Dies
26-page Bulletin 41 on application of Meehanite for forming and stamping dies. *Meehanite Metal Corp.*

825. Melting Aluminum
Folder A-5 describes automatic melting and pouring unit for production of aluminum die castings. *Ajax Eng'g.*

826. Melting Furnaces
8-page Bulletin 560 describes stationary and tilting types of two-chamber melting furnaces. Applications to all types of casting. *Lindberg Engineering*

827. Metal Cutting
64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

828. Metal Recovery
9-page reprint, "Metal Recovery by Ion Exchange". *Permutit Co.*

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20-page book on desk-type metallograph. *American Optical*

830. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories*

831. Microhardness Tester
Bulletin DH-114 on Tukon hardness testers in research and industrial testing. *Wilson Mechanical Instrument*

832. Microscopes
22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

833. Moly-Sulphide Lubricant
40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

834. Nonferrous Metals
"Metal of the Month" letters include market trends, statistics, helpful data. *Belmont Smelting & Refining*

835. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

836. Oxygen-Nitrogen Generators
12-page Bulletin 52 on tonnage and high-purity oxygen-nitrogen generators, and equipment for other low-temperature processes. *Air Products*

837. Peening
Bulletin on use of cut wire shot for peening and cleaning. *Park Chemical*

838. Pickling
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g.*

839. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

840. Piercing
Slide calculator for determining the required pressure (in tons) for piercing a given size hole in any thickness and type of metal. *Ward Machinery*

841. Pipe and Tubing
New 68-page book is a practical treatise on pipe and tube making, answering many pertinent questions on tube mill operations and production. *Yoder*

842. Pit Furnace
Bulletin 294 on ingot heating pit furnace. Performance data, drawings, amortization chart. *Amsler Morton*

843. Plating
8-page booklet on plating rack designed to make spline section or body of rack a permanent tool. *National Rack*

844. Plating
Set of bulletins on filtration equipment for plating solutions. *Sparkler*

845. Polarizing Microscopes
40-page book on polarizing microscopes, universal stages, other accessories. *E. Leitz*

846. Portable Hardness Tester
Bulletin on portable Brinell-type tester weighing 19 lb. *Blosjo Enterprises*

847. Powder Metallurgy
Information on sponge iron powder. *Ekstrand & Tholand*

848. Powder Metallurgy
32-page handbook gives 24 case histories of parts designed or redesigned for powder metal production. Cost comparisons, definitions of terms and list of standards. *New Jersey Zinc*

849. Precision Casting
12-page illustrated booklet on precision casting with emphasis on the most widely used equipment and supplies. Check list of applications in various fields. *Alexander Saunders*

850. Precision Casting
Bulletin on mechanically-operated induction furnace for precision casting. *Ajax Electrothermic*

851. Precision Casting
8-page bulletin on investment castings of ferrous and nonferrous alloys. *Engineered Precision Casting*

852. Precision Castings
8-page bulletin on design and engineering factors of precision castings. *Sessions Foundry Co.*

853. Precision Finishing
Bulletin 5212 on small dry-abrasive airblast unit for cutting hard materials and precision finishing. *S. S. White*

854. Precision Forgings
Data folder on small metal parts forged to within a few thousandths of an inch. *Utica Drop Forge*

855. Precision Grinding
8-page article on oils for precision grinding, from Notebook. *D. A. Stuart*

856. Precision Measurement
Bulletin on granite surface plates of accuracy to 0.00005 in. *Lawley*

857. Pre-Finished Metals
16-page fabrication handbook on preplated metals, ferrous and nonferrous. *American Nickeloid*

858. Process Equipment
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

859. Punching and Shearing
Bulletin on machine that combines in one unit a punch, bar and shape cutter and plate shear. *Maddaus Moelders*

860. Pyrometer Supplies
Buyers' Guide for pyrometer supplies, No. 100-4. *Minneapolis-Honeywell*

861. Pyrometers
Data sheets on high resistance indicating pyrometers. Also controls and resistance thermometers. *Taco West*

862. Pyrometers
12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *Gen. Electric*

863. Pyrometers
Information on Xactemp pyrometers; also Xactline straight-line temperature control for use with any standard controller. *Claud S. Gordon Co.*

864. Quenching
Bulletin on reasons for quenching oil failure and maintenance of quenching systems. *Industrial Filtration Co.*

865. Quenching
8-page bulletin on continuous quench tank conveyor. *Kiaas Machine & Mfg.*

866. Quenching in Holes
Bulletin on machine for quenching die holes in case hardening. *Palmer Mfg.*

867. Quenching Oil
Technical bulletin F-8 on quenching oil and accelerators to provide deeper hardening. *Park Chemical Co.*

868. Quenching Oil
8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

869. Radiography
Bulletin 400-520 on jib-crane unit for applications where horizontal and vertical travels of standard tubestand are inadequate. *Westinghouse*

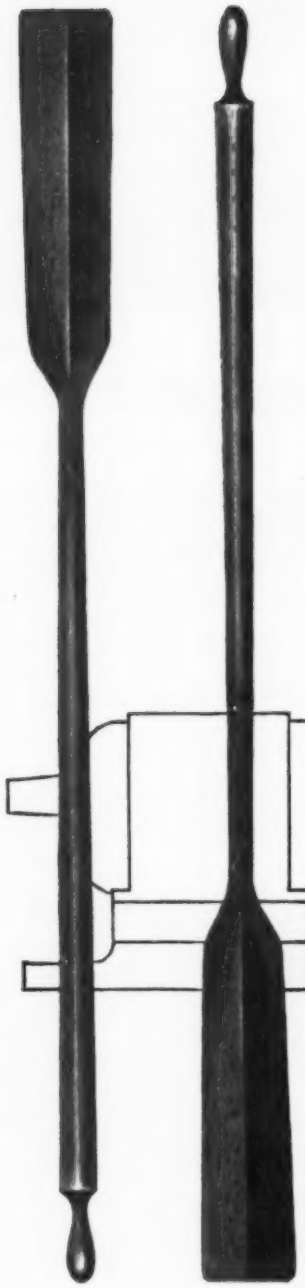
870. Radiography
16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

871. Rapid Carbon Analysis
Literature on complete line of rapid carbon analyzers for steel, cast iron, pig iron, coal, coke and oil. *Laboratory Equipment Corp.*

872. Recirculating Furnaces
16-page Bulletin 81 describes and illustrates heat treating furnaces for ferrous and nonferrous parts and other heat treat equipment. *Despatch Oven*

873. Recorder
C2-2 on strip-chart recorder. *Wheelco*

(Continued on p. 32-A)



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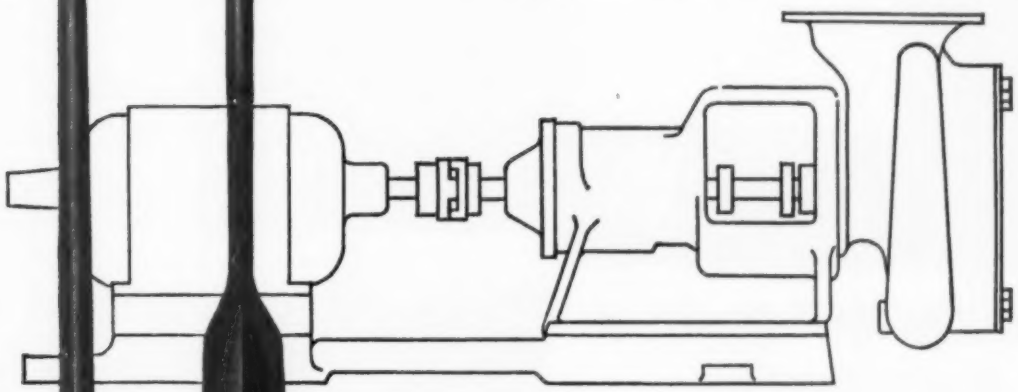

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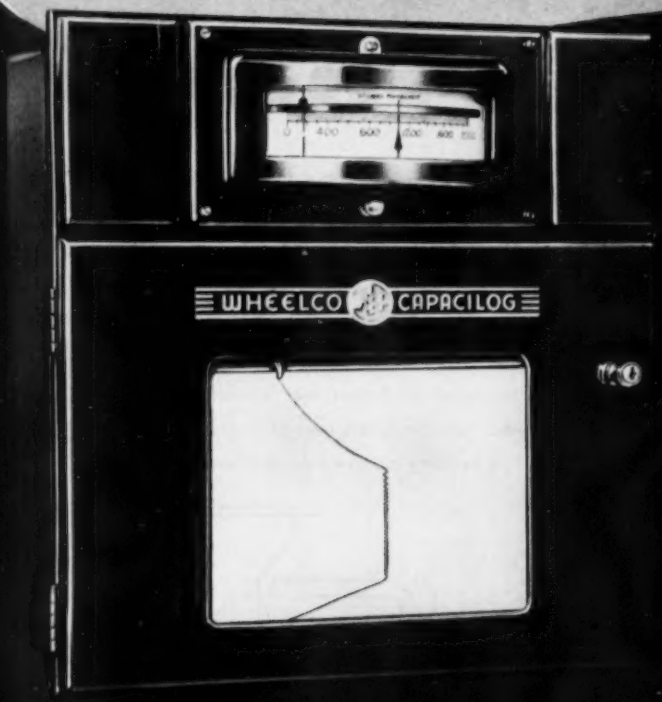

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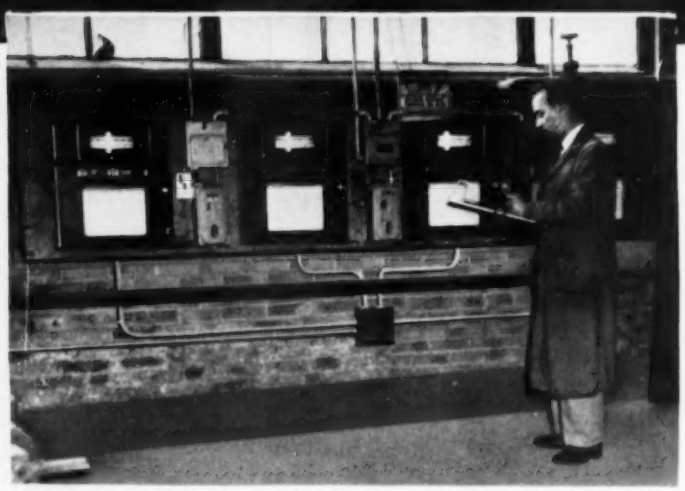

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(Continued from p. 30)

874. Recorder Controllers
48-page ND 46(1) gives specifications, installation pictures of recorders and controllers for temperature, strain, other variables. *Leeds & Northrup*

875. Reverse-Current Cleaner
Bulletin on electrocleaner 12 for steel, copper and brass with either reverse or direct current. *Diversey*

876. Refractories
12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

877. Refractories
20-page booklet gives technical information on super refractories. Charts, tables and application data. *Refractories Div., Carborundum Co.*

878. Refractory Cement
Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

879. Rhodium Plating
Rhodium plating as replacement for usual plating metals. *Baker & Co.*

880. Rust Preventive
Bulletin 22 on water-soluble rust preventive for cast iron and steel. *Production Specialties*

881. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

882. Salt Baths
32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

883. Salt Baths
16-page bulletin "A Lap Full of Problems" gives eight case histories on salt bath heat treating. *American Cyanamid*

884. Sealing Porous Castings
Technical Report 128A on synthetic resin for sealing porous castings. *Chemical Div., General Electric*

885. Selective Heat Treating
Reprint on selective heat treating in a salt bath. *Ajax Electric*

886. Shearing
Folder on high-production billet shear with electromagnetic hold-down. *Maddaus Moelders*

887. Sheet Metal Testing
8-page folder on equipment for testing the drawing, stamping and folding qualities of sheet and strip. *Deakin*

888. Sheet Steel Separator
Data on magnetic device for automatic separation of stacked steel sheets. *Barco Mfg.*

889. Shot Peening
Selection and use of shot and grit for peening. *Cleveland Metal Abrasive*

890. Sintered Carbides
32-page bulletin on applications of carbides for tools, punches, dies and wear parts. *Allegheny Ludlum*

891. Slitting
76-page book on slitting lines for coils and sheets. Design, selection, operation, time studies of operating cycle. *Yoder*

892. Sonic Thickness Tester
Measurement of wall thickness from one side by sonic method. *Branson*

893. Specification Key
Guide to Government specifications for phosphatizing, rust-proofing and paint bonding chemicals. *American Chemical Paint*

894. Specimen Cutting
Folder describes complete line of cut-off machines. Five models for samples from ½ to 3 in. dia. *Buehler Ltd.*

895. Spectrophotometer
Bulletin B-211 on junior-size spectrophotometer for identifying and measuring solution constituents. *Harshaw*

896. Spring Steels
Spring steel catalog offers 785 sizes of hardened and tempered spring steels, and 133 cold-rolled and bright annealed sizes in stock. *Sandvik Steel*

897. Spring Tester
Bulletin on machine for testing compression and tension springs. *Testing Equipment Co.*

898. Stainless Castings
Bulletin on advantages of corrosion-resistant castings. *Ohio Steel Foundry*

899. Stainless Steel
44-page book gives detailed information on use of stainless steel in the chemical industries. *Crucible Steel*

900. Stainless Steel
8-page guide to Enduro stainless gives composition, physical, electrical and mechanical properties of 300 and 400 series. Corrosion data. *Republic Steel*

901. Stainless Tubing
8-page bulletin on corrosion-resistant tubing and fabricated piping. *Youngstown Welding & Engineering*

902. Stainless Tubing
8-page bulletin on stainless steel tubing and pipe. *Damascus Tube Co.*

903. Stampings
24-page book gives analyses
stamped parts as examples of e
ing range. *Crosby Co.*

904. Steel, Low-Alloy
8-page folder on N-A-X lo
high-strength steels. *Crcat La*

905. Steel Tubes
12-page Bulletin 103 on s
alloy and carbon steel tubes, s
and welded. *Globe Steel Tubes*

906. Stress Analysis
Bulletin 5 on equipment for str
ysis with SR-4 strain gages. *Ell*

907. Subzero Freezer
Data on chest for use down to
for production use and testing.

908. Subzero Freezer
8-page folder on portable
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shrink fitting, hardening, st
and testing. *Webber Appliance*

909. Subzero Treatment
Advantages of low-temperatu
treatment are described in a
page folder. Processes covered
stabilization, increasing tool
shrink-fit assembly. *Sub-Zero*

910. Surface Pyrometer
Bulletin 168 on instrument fo
accurate readings of surface t
tures. *Pyrometer Instrument*

911. Surface Roughness
Bulletin on roughness compar
having surfaces finished to
micro-inch readings. *Acme In*

912. Surface Temperatu
Pyrocon bulletin on hand-he
mocouple-type instrument for
ing and indicating surface temp
at exact locations. *Illinois Testi*

913. Temperature Contr
Catalog of pyrometer suppli
data on thermocouples, protecti
other accessories. *Arklay S.*

914. Tempering
Bulletin 1E 11 on temperi
other applications in liquid bath

915. Tempering
Reprint of article on contro
mosphere tempering. *Ipsen*

916. Test Accessories
22-page Bulletin 46 on instr
tion, tools and accessories for n
cal testing machines. *Tinius O*

917. Test for Heat Check
Folder on test apparatus fo
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steels. *Henry G. Keshian*

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918. Test Specimens
Common metals and alloys mounted and identified. Photomicrographs, analyses, hardness data for comparison or teaching. *Adolph I. Buehler*

919. Testing
Booklet on Reflectoscope tells how ultrasonic vibrations penetrate up to 24 feet to "see" internal defects and fatigue cracks. *Sperry Products*

920. Testing Machines
32-page catalog on hydraulic testing machines. 10 models described; also accessories. *Riehle*

921. Textured Stainless
Folder on stainless to conserve alloys and reduce weight. *Rigidized Metals*

922. Thermocouple Data
42-page Bulletin TC-9 on thermocouples, radiation detectors, resistance bulbs, accessories. *Wheelco*

923. Thermocouples
44-page catalog EN-S2 describes couples and assemblies for general application and for special plant and laboratory uses. Tabular data on accuracy and limits of couples. *Leeds & Northrup*

924. Thickness Gaging
28-page bulletin on continuous gages and controls for thickness and width of sheet, foil and wire. *Pratt & Whitney*

925. Tong Ammeters
Bulletin on tong test ammeters, a.c. or d.c., for instant current measurements without breaking circuit or touching conductor. *Columbia Electric*

926. Tool and Die Steels
26-page book on six oil and air hardening steels for high-production tools and dies. Uses. *Bethlehem Steel*

927. Tool Furnace
17-page Bulletin 1054 on tool hardening equipment. *Sentry*

928. Tool Steel
Effect of carbide segregation in tool steel. *Latrobe Steel*

929. Tool Steel Heat Treat
Bulletin 1147EE on electric furnace for heat treatment of high speed tool steel. *Hevi Duty*

930. Tool Steel Selector
Selector is handy chart featuring general and heat treating data on non-deforming, water hardening, shock-resistant, hot work, high speed tool and hollow die steels. *A. Milne & Co.*

931. Tool Steels
Stock list of available tool and die steels. *Reliable Steel*

932. Tube Straightening
Catalog describes two-roll rotary straightener for round tubes and bars 1/16 to 3/16 in. O.D. *Medart Co.*

933. Tubes and Bars, Steel
New stock list on 52100 tubing, bars, and ring forgings. *Peterson Steels*

934. Tubing
Bulletin 32 on analyses available, production limits, commercial tolerances, temper designations of seamless and weldrawn tubing. *Superior Tube*

935. Shot Blasting
This book, written in question and answer form, deals with such topics as the time factor in

cleaning or peening, advantages and disadvantages of both chilled iron and annealed iron abrasives, and the importance of maintenance costs and abrasive costs. *Hickman, Williams & Co.*

936. Tubing
12-page data book on brazed tubing made from copper-coated steel. *Bundy*

937. Tungsten Carbide
72-page catalog on tungsten carbide products, including tools, dies, gages, rolls. *Metal Carbides Corp.*

938. Ultrasonic Inspection
Set of application sheets, each describing a specific use for ultrasonic inspection. *Sperry Products*

939. Vacuum Pumps
Bulletin V-51B describes line of vacuum pumps. *Kinney Mfg.*

940. Weld-Rod Dehydrating
Bulletin on low-hydrogen electrode stabilizer. Specifications of equipment for dehydrating mineral shielding or low-hydrogen electrodes. *Archer*

941. Welding Cast Iron
Bulletin on electrodes for machinable welds on cast iron. *Alloy Rods*

942. Welding Electrodes
Comparison chart of brand names of 16 manufacturers of low-hydrogen electrodes. *Arcos*

943. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

944. Welding Pressure Vessels
Reprint describes procedures for welding stainless, stainless-clad and copper alloy pressure vessels and refinery components. *Air Reduction*

945. White Brass Plating
Procedure for white brass plating. *Promat Div.*

946. Wire Mesh Belts
140-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

947. Wire Straightening
Bulletin 52-C describes precision machine for straightening small wire with extreme accuracy. Applies to round wire 0.007 to 0.125 in. diameter of ferrous or nonferrous metal. *Medart Co.*

948. X-Ray Accessories
248-page catalog and supplement on materials used in X-ray inspection. *Picker X-Ray*

949. X-Ray Spectrography
Publication AO-11, "Metallurgical Applications of X-Ray Fluorescent Analysis". *X-Ray Dept., General Electric*

950. Zinc and Cadmium Plate
Technical data sheets on use of Luster-on salts for zinc and cadmium plating. *Chemical Corp.*

951. Zircon Ware
20-page bulletin on zircon refractory ware for laboratory use. *Laboratory Equipment Corp.*

952. Zirconium
26-page booklet gives physical, mechanical and chemical properties, present and potential uses, supply and prices of zirconium. *Zirconium Metals*

March, 1953

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612	637	662	687	712	737	762	787	812	837	862	887	912	937
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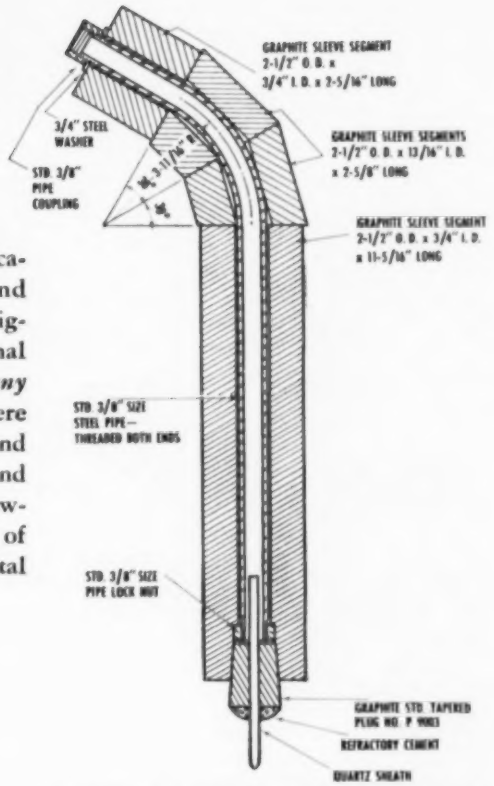

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ALOXITE TP Aluminum Oxide	Tough, blocky. Standard grit sizes from 16 through 220.	Polishing operations involving heavy stock removal on steel and other high tensile strength metals.
ALOXITE TPT Aluminum Oxide	Tough, sharp. Grits 16 through 100.	Polishing operations involving removal of large amounts of metal (e.g. plowshares).
ALOXITE TPL Aluminum Oxide	Very sharp, friable. Grits 16 through 220. (It fractures during use, thus reduces loading of the wheel surface).	Polishing low tensile strength metals—copper, brass, bronze, aluminum.
ALOXITE TPC Aluminum Oxide	Medium sharp. Grits 16 through 220.	General purpose polishing grain—for removal of small amounts of metal.
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CARBORUNDUM RA Silicon Carbide	Sharp, very friable. Grits 10 through 240.	Polishing cast iron.
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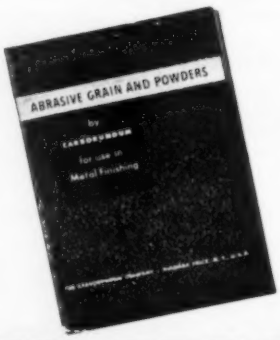

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Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Invisible Cracks and How They Were Cured

One of our customers reported trouble with a roll used in the making of fine silverware. Made of A-H5, our 5-pct chromium air-hardening steel, the roll was of 6-in. diameter with a 10-in. working face, highly polished. It worked fine at first. Then a fine network began to show up on the silverware being rolled.

We suggested that the customer bring the roll to our plant, where we have the most modern facilities for diagnosing ailing tools and dies. When the roll was magnetic-particle tested, what appeared to the eye as a beautifully polished surface was revealed to be a fine network of grinding cracks.

"Never had that kind of cracks before," said the customer. "Can we get rid of them on a roll of such high hardness?"

"Yes," we replied. "But it's going to be a tricky job." So we checked with the experts in our division that produces hardened steel rolls. "It's not easy," they told us, "but it can be done. Use a wheel with a very coarse grit with a soft binder. Remove the surface at a maximum rate of .0005 in. per pass. You'll clean up the cracks somewhere between .005 and .010 in."

Then we checked with our specialist on grinding wheels, who gave us the exact code numbers for the grades of wheels that would make it possible to salvage the roll—and also prevent the recurrence of grinding cracks. Our customer went away well satisfied . . . and he's still using A-H5 with fine results.

Bring your tool or die troubles to our technical staff for advice that's based on years of practical experience—not just in making fine tool steel and in helping customers solve their problems, but in using hundreds of tons of our own tool steel each year in our manufacturing divisions. Perhaps we can help *you!*

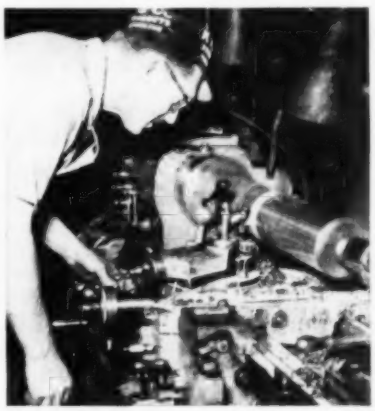
This piece of Omega tool steel, tops in resistance to cold shock, will see service as a retainer block for a header die that is subjected to terrific loads in the cold-heading of steel artillery shell cases.

Some rough forgings of Lehigh S tool steel provide an interesting contrast to the finished liner for a tapering die which puts the desired taper on a 105-mm shell case after it has been headed.

COLD-EXTRUDING CALLS FOR GOOD TOOL STEEL

Great advances are being made in the technique of cold-extruding steel. It's a development that opens up new horizons in metalworking. The severity of this type of work calls for a variety of blue-ribbon tool steels—some must have the ultimate in wear-resistance, others must withstand terrific shock.

Bethlehem tool steels are in plentiful evidence wherever cold-extrusion tools and dies are being made. The accompanying photographs, made at Carando Machine Works, Stockton, Calif., show punches and dies being made from Bethlehem tool steels for use in the cold-extrusion of steel shell cases.



A bar of Lehigh S is being turned in a lathe to form a draw punch for a 3-in. cartridge case. Lehigh S has the highest wear-resistance of Bethlehem's high-carbon, high-chromium grades. It also holds to accurate size in heat-treatment.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

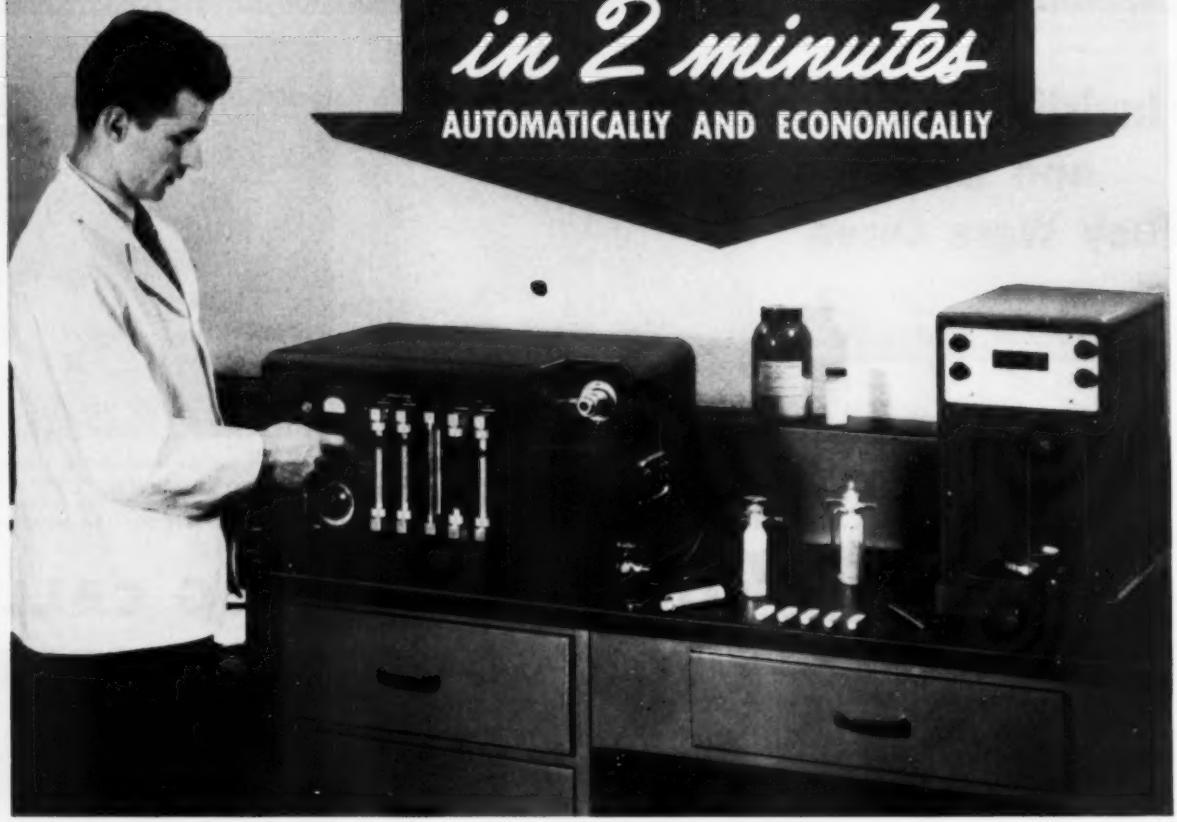
Avoid sharp corners in designing tools

Tools designed with sharp corners, such as in square holes, can often be produced satisfactorily when liquid-quenched tool steel is used. However, such designs are often so hazardous that a large percentage of cracked tools can be expected, no matter how carefully the heat-treatment is performed.

When the sharp corners are not necessary, the solution is of course to provide fillets. But when square holes or other sharp corners are essential in the design of the tool, the use of an air-hardening steel is recommended.

Accurate CARBON ANALYSIS *in 2 minutes*

AUTOMATICALLY AND ECONOMICALLY



THE FISHER INDUCTION CARBON APPARATUS is a completely automatic high-frequency induction apparatus which makes possible rapid and accurate determinations in all types of ferrous metals, from steels with low carbon content to stainless steels and cast irons.

This apparatus has been used successfully in both gravimetric and volumetric analyses. It produces extremely high temperatures (in excess of 3000° F.) and has a built-in purification and absorption train. It will accommodate a full factor weight of 2.727 grams.

From the time the sample is introduced into the quartz combustion tube until the final weighing or volume measurement is made, the cycle of operation is only two minutes.

The cost of carbon determinations is materially decreased since it takes one-fourth the time to run an analysis with the Fisher apparatus compared to the time required for conventional hot-tube methods. Also, it requires no pre-heating time and is in operation only during actual test.

The Fisher Induction Carbon Apparatus is furnished complete with built-in train, chemicals for absorbers, quartz combustion chamber, automatic controls and a boat positioning tool.

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Complete stocks of laboratory instruments, apparatus, reagent chemicals, and furniture at Pittsburgh, 717 Forbes St., (19) • New York, 635 Greenwich St., (14) • St. Louis, 2850 S. Jefferson Ave., (18) • Washington, 7722 Woodbury Drive, Silver Spring, Md. • Montreal, 904 St. James, P.Q., Canada • Toronto, 245 Carlaw Ave., (8), P.O., Canada.

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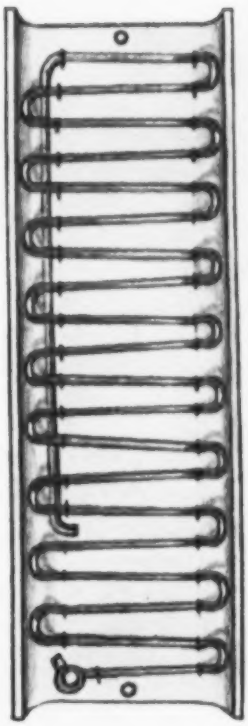
FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*

REFRIGERATOR CONDENSER



REMARKS What's your tubing problem? Are competitors gaining an edge while you iron out design or fabrication kinks? Are unexpected tubing failures eating into profits? Skilled Bundy engineers can help solve that design or fabrication problem; save time, materials, money. And dependable Bundyweld Tubing will help eliminate those annoying, sometimes costly, failures.

WRITE today for catalog or for help on your tubing idea or problem.
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Bundyweld Tubing

® DOUBLE-WALLED FROM A SINGLE STRIP

Leakproof
High thermal conductivity
High bursting point
High endurance limit
Extra-strong
Shock-resistant
Ductile

Lightweight
Machines easily
Takes plastic coating
Scale-free
Bright and clean
No inside bead
Uniform I.D., O.D.

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive patented Bundyweld beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

Bundy Tubing Distributors and Representatives: ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave. South ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing is sold by distributors of nickel and nickel alloys in principal cities.**

Every Man Responsible for Tooling and Production Can Take This Step Now and Get Results!

Re-check your *tools* and *dies* . . . investigate this immediate source for new cost economies like hundreds of other plants are doing! You'll often be able to reduce costly die maintenance, shutdowns for regrinding . . . and step up output between grinds.

Records in hundreds of plants prove it possible. Look at the job shown above. A re-check of these punches and dies that produce muffler heads on an automatic transfer press, showed that a different die steel with the following properties was needed: (1) More uniform, through hardening, (2) Higher wear resistance, (3) Greater safety and accuracy in heat treatment. It was found that all of these properties were provided by *one* tool steel—Carpenter No. 610 (Air-Wear). Now, after many months of dependable service, the No. 610 tools are still averaging 200,000 units per month, and costs are in line.

One such case is not complete proof. But when many other plants report similar cases of cost relief, it adds up to an opportunity for you. Try this now: Use the Carpenter Matched Set Method to select the one steel best suited to cut costs. This Method is backed by *dependable* tool and die steels that stay on the job. Then, for rush delivery, call your nearest Carpenter Mill-Branch Warehouse or Distributor. THE CARPENTER STEEL CO., 133 W. BERN ST., READING, PA.

Are You Missing These Opportunities In Your Cost Relief Zone?

- Less die finishing and adjusting
- Greater output between grinds
- Fewer heat treating failures
- Less machine downtime

On Job After Job Carpenter Matched Tool and Die Steels Have Made Them Possible!

Carpenter STEEL

Matched Tool and Die Steels

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Principal Cities Throughout the U. S. A. and Canada

Cities Service Cutting Oils Proved The Very Best By Micrometer Test!

CUTTER MEASURED WITH MICROMETER. As a final test, Automatic Pencil Sharpener measures each cutter with a micrometer. All tests proved that Cities Service cutting oil was absolutely tops for this really tough job.

STRICT SPECIFICATIONS REQUIRE FINEST CUTTING OIL. APSCO Sharpeners offer many more features than other brands. To produce their top quality product, Spengler-Loomis relies on top-quality lubrication products . . . Cities Service Products, famous throughout industry.

ONLY .005 INCHES BURR OR BUILD-UP ALLOWED IN FIFTY-HOUR OPERATION CUTTING GROOVE IN B1112 STEEL!

Says Mr. C. J. Kostrzewa, Plant Superintendent: "Cutting oil requirements in our Automatic Pencil Sharpener Division are tough. To find the right coolant, we called for, and tested, samples from various companies. Over a period of testing time, we used graphs, charts and tables, keeping a running record on all coolants. As a final test, we measured the cutter with a micrometer before and after milling. The cutting oil that came out tops was Cities Service.

"I'd also like to point out that the Cities Service Engineering staff co-operated fully by offering helpful advice and excellent service."

Why not discuss your lubrication problems with a Cities Service lubrication engineer? Write Cities Service Oil Company, Dept. C14, Sixty Wall Tower, New York 5, New York—or contact your nearest Cities Service office.

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QUALITY PETROLEUM PRODUCTS

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Also Available for Immediate Delivery

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Please feel free to consult our engineering staff on your problems in brazing, upsetting, annealing, hardening of metals or for quotations on the design and manufacture of fixtures for Induction and Dielectric Heating.

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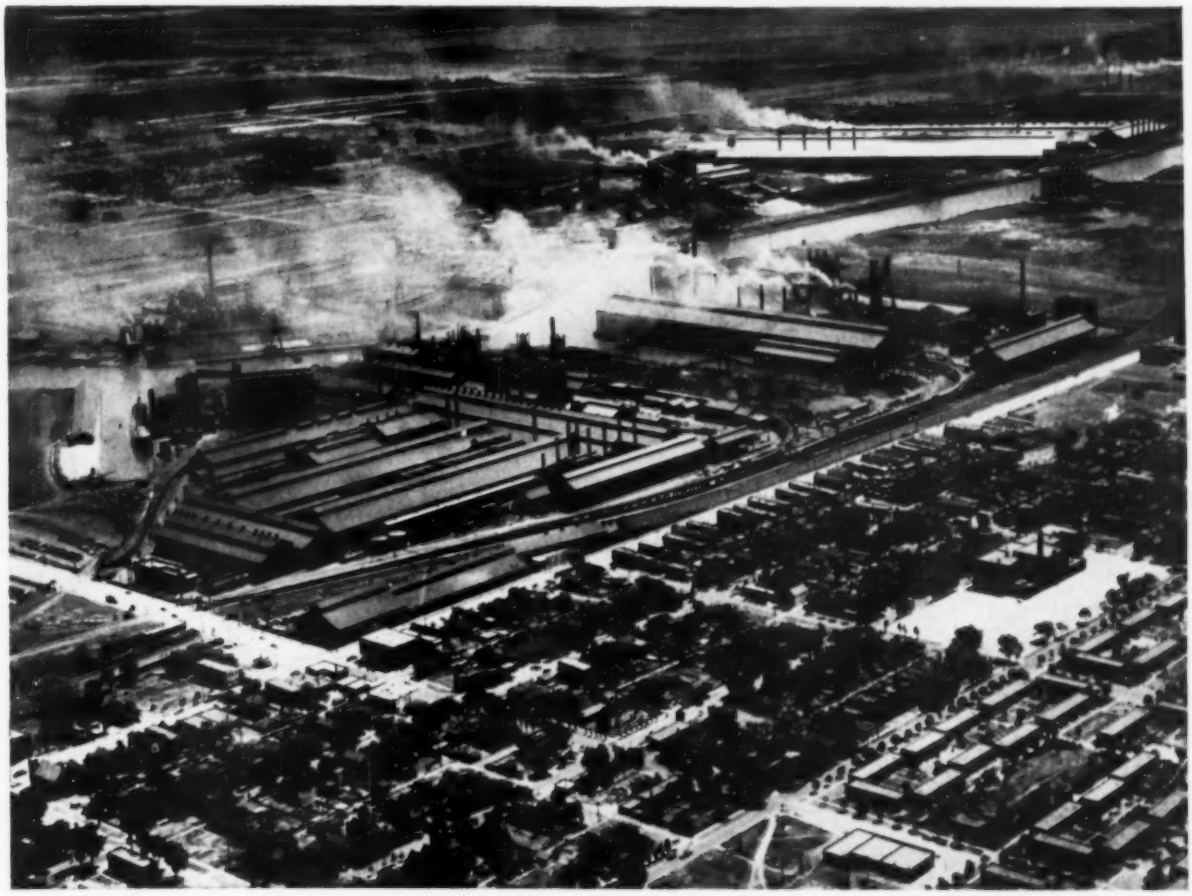
We have available a specially equipped mobile unit to test, correct and certify Induction and Dielectric units against radio and TV interference in accordance with F. C. C. regulations. Write or call for quotations. NE 2-5555.

WISCONSIN STEEL



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HOT-ROLLED BAR MILL PRODUCTS
Rounds—Squares—Flats—Bar-Size Angles and Channels—Spring Steel and Special Sections

HOT-ROLLED STRIPS

STRUCTURAL SHAPES
Angles, Channels and Special Sections

COLD-FINISHED PRODUCTS
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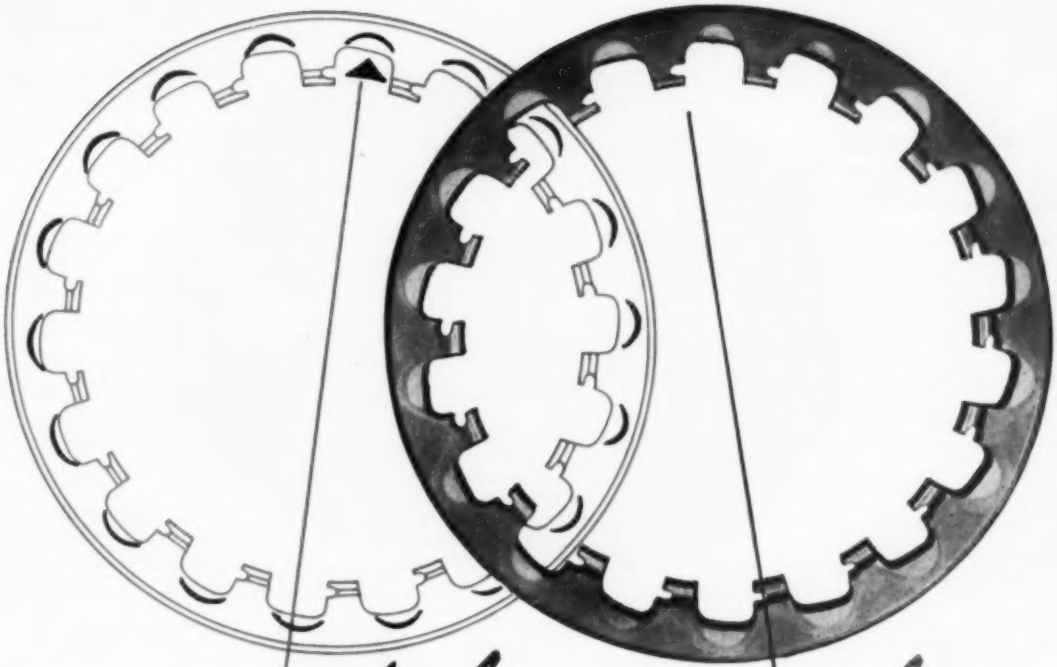


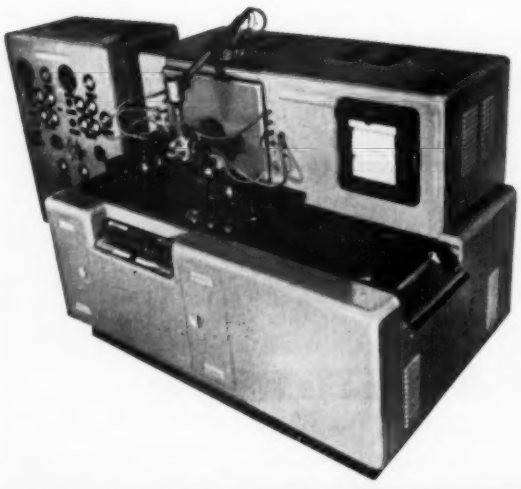
specified | *achieved*

definite hardness pattern | **excellent uniformity**

high production | **60 parts per hour**

distortion next to nothing | **rejects virtually nil**

with flamatic selective surface hardening



If ever there was one, here's a really tough heat treat job. The print called for all 18 internal lobes of this tank transmission cam (SAE 3145) to be hardened to Rc 53-60, body between lobes to remain ductile, pattern so consistent that inspection of only 1% of production would be permissible.

The nital etched section shown above (about half size) clearly shows the results achieved by Flamatic selective hardening. Production of 60 parts per hour was ten times faster than previous method. Scrap losses dropped practically to zero.

Gears, cams, rollers, parts with multiple diameters, etc., up to 18" OD depending on width or shafts up to 24" long depending on OD are readily handled on the Standard Flamatic. Write for Catalog No. M-1724 which includes case histories. Send part prints for analysis and recommendations.

flamatic

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Cincinnati 9, Ohio, U.S.A.

CINCINNATI

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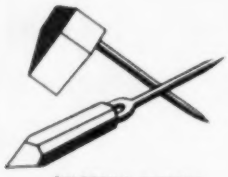
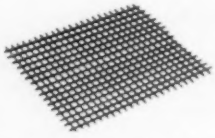


SOLDERING COPPERS



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INDUSTRIAL and AUTOMOTIVE FITTINGS

PERFORATED METAL IN BRASS, BRONZE and COPPER

BEARING BRONZE BARS

CALL US FOR ANYTHING from Bearing Bronze Bars to Brass or Bronze Bolts . . . or any other brass or copper item for maintenance, repair, operating or production.

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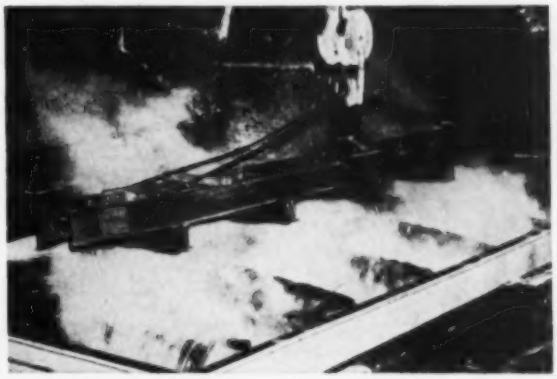
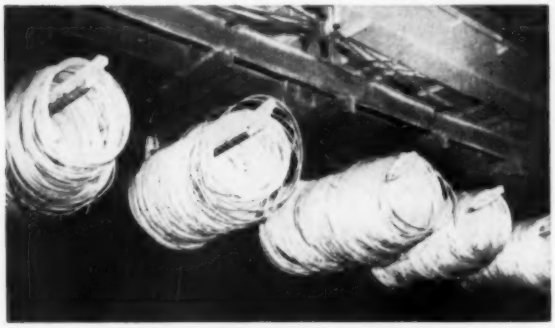
Boston	Dallas	Indianapolis	Minneapolis	Philadelphia	St. Louis	(†sales office only)

Descaling 5 tons of stainless wire *IN 15 MINUTES* with VIRGO® Descaling Salt

10-MINUTE IMMERSION in molten bath of Virgo Descaling Salt at 900°F. loosens scale. The bath is self-regenerating, and produces no toxic fumes. Immersion time and temperature are flexible, need not be watched closely.



WATER QUENCH removes much of the loose scale. The steam generated by immersing the hot metal in the water further loosens scale by its blasting action. The work is thus prepared for the final acid dip.



THREE-MINUTE DIP in dilute acid removes the now soluble scale. The work is ready for a rinse or hosing to wash off the acid. **Result: a chemically clean surface—no pitting, etching or metal loss.** TOTAL TIME—15 MINUTES.

VIRGO DESCALING SALT—Producers and fabricators of stainless and alloy steels use Virgo Descaling Salt to quickly, positively remove scale produced by hot rolling, forging, extruding, casting, annealing.

VIRGO MOLTEN CLEANER—quickly, positively desands and degraphitizes castings; removes grease, dirt, chemicals, paint, enamel, rubber, atmospheric corrosion and other impurities.

This process can be used on steel; castings; forgings; fabricated parts; material to be salvaged. It employs simple equipment, and is easily adapted to your production methods.

SEND FOR THESE BULLETINS—Get the whole story on Virgo Descaling Salt and Virgo Molten Cleaner—what they are, how they work, their advantages, how they fit your operations, and the Hooker services you enjoy as a user of the process. Send for these bulletins today.

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1-1443

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Please send me Bulletins checked: Virgo Descaling Salt ☐ Virgo Molten Cleaner ☐

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Superior

TYPE 430 STAINLESS STRIP STEEL

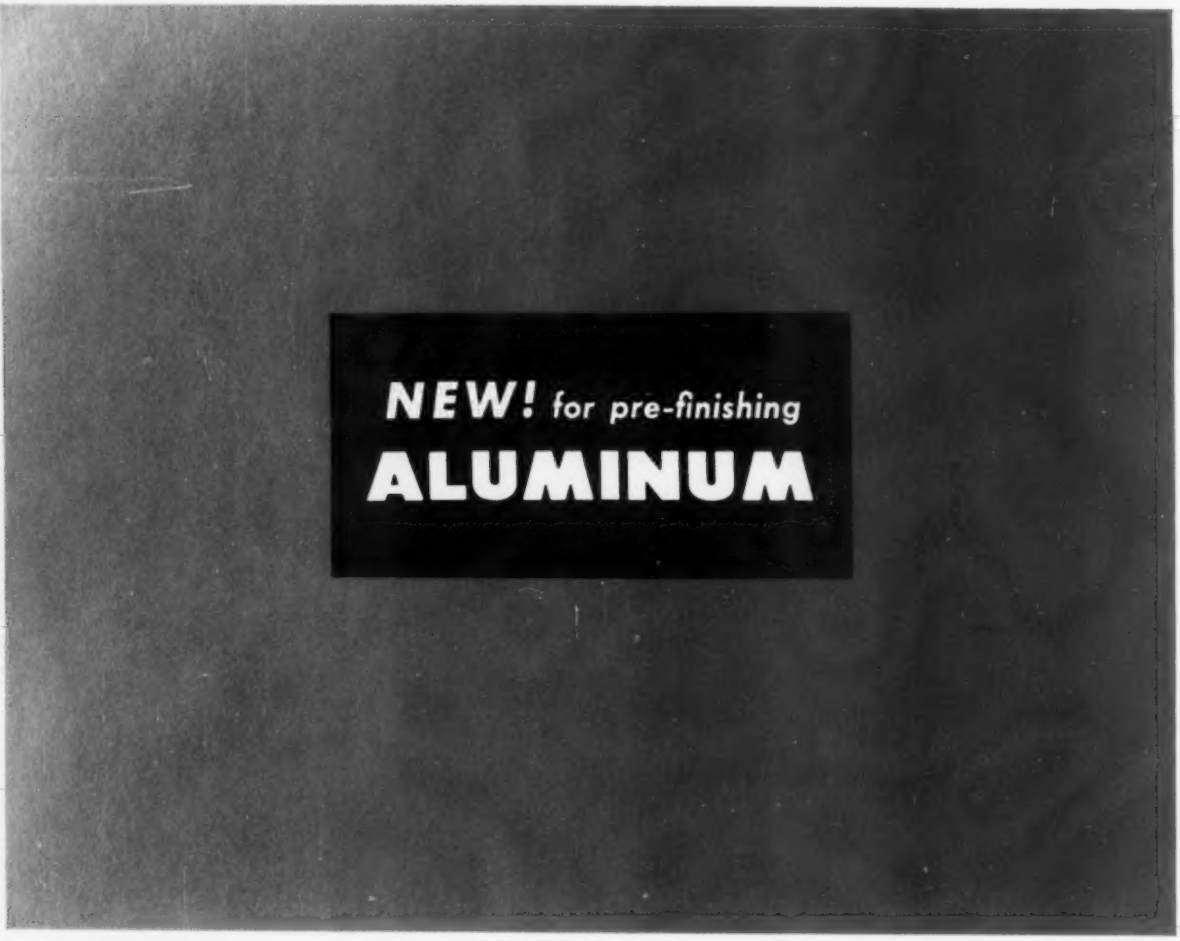
The luster of Superior 430 Stainless Strip Steel conveys more than sparkling beauty in the bathroom. Its brilliance speaks of triumph over rust and corrosion, where dampness and moisture abound. • Superior 430 Stainless Strip Steel is your ideal choice for fixture fabrication. Its *work-ability* is outstanding. Its brilliant luster, ease of cleaning and strength in service are most desirable sales advantages.

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

Do you have a tough moisture-corrosion problem?

Our 430 Stainless is available in easy-handling coils. Let us serve you!

MORE FACTS ON GETTING "A BETTER START FOR YOUR FINISH"



PENNSALT NOW OFFERS A COMPLETE "PACKAGE"

Five specialized products—three brand new—for preparing aluminum prior to anodizing, chromatizing, or other finishing methods

Here's a versatile new group of materials that will be of major interest to everyone concerned with the finishing of aluminum. One or more of these outstanding products can help finishers do a faster, safer, more economical, and considerably better job—on any grade or alloy of aluminum, and in conjunction with any type of finishing.

First of the three new products in this "package" is **Pennsalt Cleaner A-27**—a mild, non-etching aluminum cleaner that removes soils and marking inks without attacking the metal. Even when allowed to dry on the work, it will not streak or stain. Yet this superior cleaner costs the same as or less than competitive cleaners.

Second in the group is Pennsalt Cleaner AE-16—a new non-scaling, non-sludging etchant that produces an exceptionally uniform satin etch. AE-16 solutions stay in balance, are easy to control, and work fast. Tank cleaning with AE-16 can be done with just a stream of water—no more rock-like scale that requires hand-chipping.

Third new product is Pennsalt Aldox—a powdered acid-type desmutter and deoxidizer. Aldox completely replaces nitric acid in these jobs—gives you an easy-to-handle, safe powder which doesn't produce irritating fumes. Aldox desmuts to give a brighter surface than acid; it deoxidizes to provide a low SCR for spot welding.

The two time-tested cleaners which complete the "package" are **Pennsalt Cleaners 85** and **MC-1**—recommended for use wherever excessive grease, dirt, or an uneven oxide film must be removed before etching the aluminum.

A COMPLETE TECHNICAL SERVICE is available to help you choose and use these Pennsalt surface-preparation materials in the most efficient, most economical manner on your particular aluminum products.

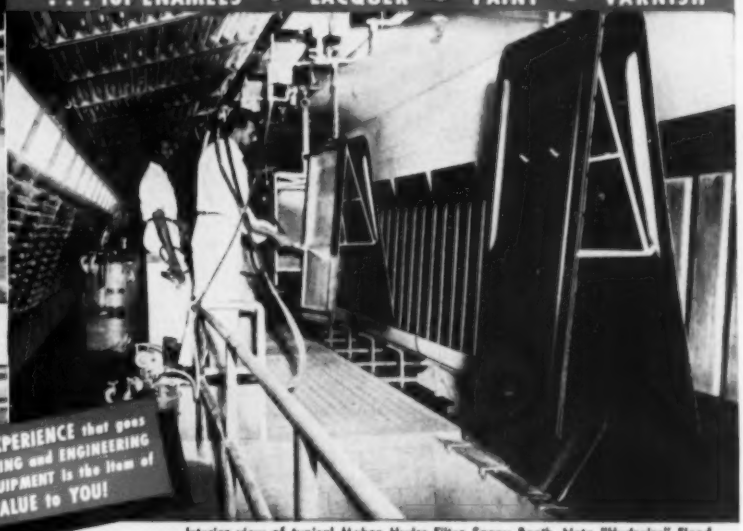
We shall gladly send you detailed information or have a representative call at your convenience. Write: Metal Processing Dept., Pennsylvania Salt Manufacturing Co., *EAST:* 112 Widener Bldg., Phila. 7, Pa. *WEST:* Woolsey Bldg., 2168 Shattuck Ave., Berkeley 4, Calif.

Pennsalt Chemicals

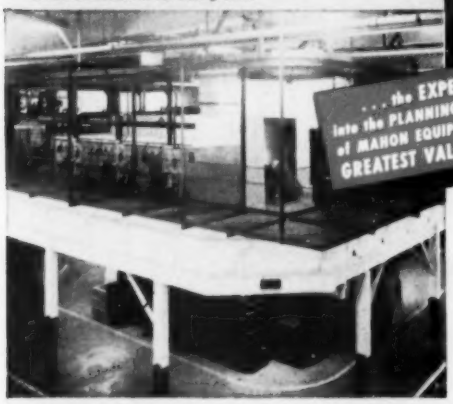
COMPLETE *Finishing* SYSTEMS

. . . for ENAMELS • LACQUER • PAINT • VARNISH

General view of Mahon Installation showing air Supply System overhead in foreground and bottom entrance Finish Baking Ovens overhead in the background.

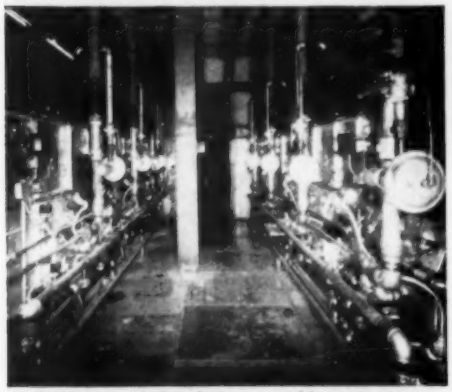


Interior view of typical Mahon Hydro-Filter Spray Booth. Note "Hydraire" Flood Sheet and "Microfusers" which provide perfect control of air flow in working area of the booth.



. . . the EXPERIENCE that goes into the PLANNING and ENGINEERING of MAHON EQUIPMENT is the item of GREATEST VALUE to YOU!

Indirect Gas-Fired Heating Units for Mahon Finish Bake Ovens and all Recirculating and Exhaust Fans are also located overhead to save manufacturing floor space.



Gas Burners and part of the Automatic Control Equipment necessary to maintain constant prescribed temperatures in the various Stages of a Modern Mahon Finish Baking Oven.

Modern Equipment Pays Dividends in Finer Finish, Lower Cost, and Better Working Conditions!

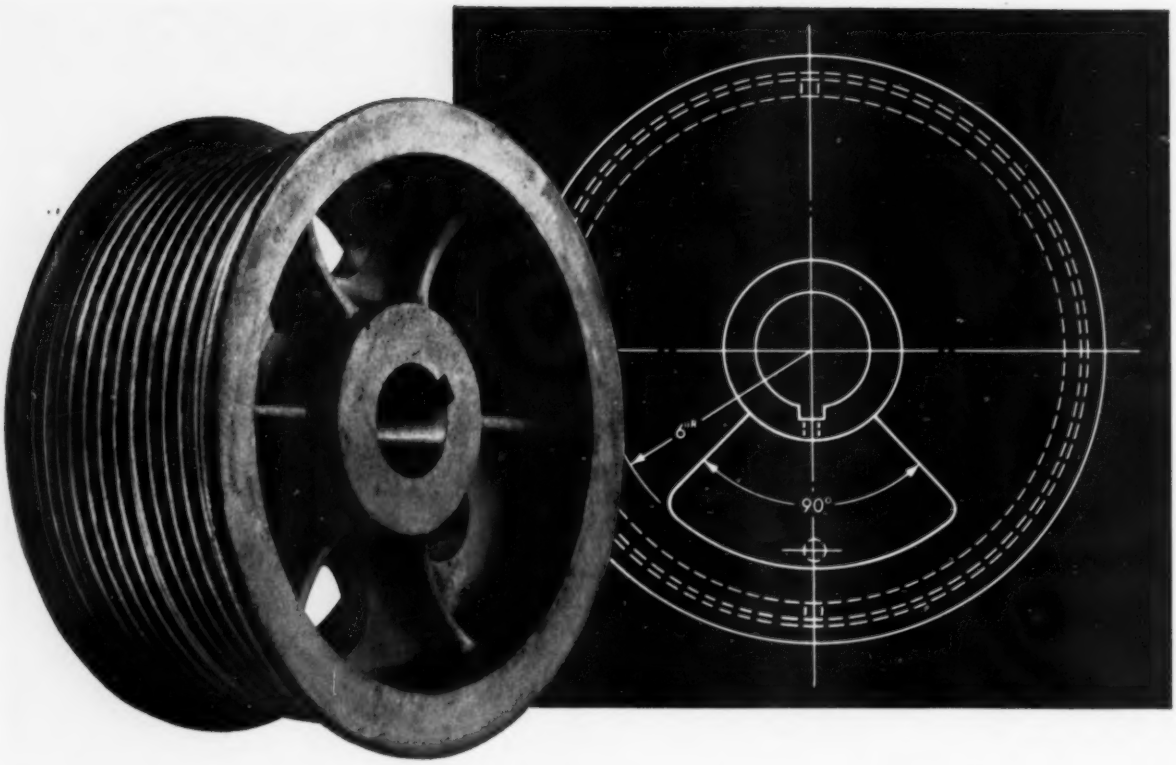
Production Finishing Equipment is constantly being improved . . . new developments such as the Mahon Fire-Jet solution heating units for cleaning and rust proofing equipment, better control of air flow in the working area of the Mahon Hydro-Filter Spray Booths, improved Flow-Coaters, automatic and conventional Dip Coaters, better automatic control of heat stages in Mahon Finish Baking Ovens, new Vacuum Booths, and many other improvements which are the result of constant research and development carried on by the Mahon Company in search of better methods which result in finer finishes at lower cost. The equipment illustrated here was recently installed in the plant of one of the world's largest home appliance manufacturers . . . it is ultramodern in every respect. If you are contemplating new finishing equipment, you will find Mahon engineers are better qualified to determine your equipment requirements and to plan and produce the most efficient production finishing equipment available today . . . equipment which will prove to be the most economical from a standpoint of maintenance and operating cost. Remember, Mahon has pioneered in this highly specialized field for over thirty years . . . remember, also, that more automobiles and more home appliances are finished in Mahon Finishing Systems than all other types combined. See Sweet's Plant Engineering File for further information, or write for Catalog A-653

THE R. C. MAHON COMPANY

HOME OFFICE and PLANT, Detroit 34, Mich. • WESTERN SALES DIVISION, Chicago 4, Ill.

Engineers and Manufacturers of Complete Finishing Systems—including Metal Cleaning and Pickling Equipment, Metal Cleaning and Rust Proofing Equipment, Hydro-Filter Spray Booths, Filtered Air Supply Systems, and Drying and Baking Ovens; Core Ovens, Heat Treating and Quenching Equipment for Aluminum and Magnesium, and other units of Special Production Equipment.

MAHON



Costly to fabricate ECONOMICAL TO CAST IN GRAY IRON!

GRAY IRON Characteristics Include:

- Castability
- Rigidity
- Low Notch Sensitivity
- Wear Resistance
- Heat Resistance
- Corrosion Resistance
- Durability
- Vibration Absorption
- Machinability
- Wide Strength Range

The cable drum, shown above, was formerly produced by using plates of various thickness—cutting, assembling, welding and finally machining. Valuable and costly man-hours were expended in co-ordinating the efforts of the several mechanics involved in these operations. Thus, supervisory costs were added to high fabrication costs.

By redesigning the part as a Gray Iron casting, a cost saving of 41% per unit was effected. On a typical order involving 20 castings, the net saving to the customer was $197, *after* initial pattern cost had been written off. Note that grooves are *cast in* instead of machined, effecting a substantial saving in machining time.

In addition to these savings, much longer operating life can be expected, because of Gray Iron's superior resistance to metal-to-metal wear and galling.

Don't miss opportunities like this to save man-hours, cut costs, and increase operating life by *redesigning in Gray Iron!* Write for technical information on advantages of the Gray Iron casting process.

Make it Better with Gray Iron • **Second largest industry in the Metal-working field**

GRAY IRON FOUNDERS' SOCIETY, INC.

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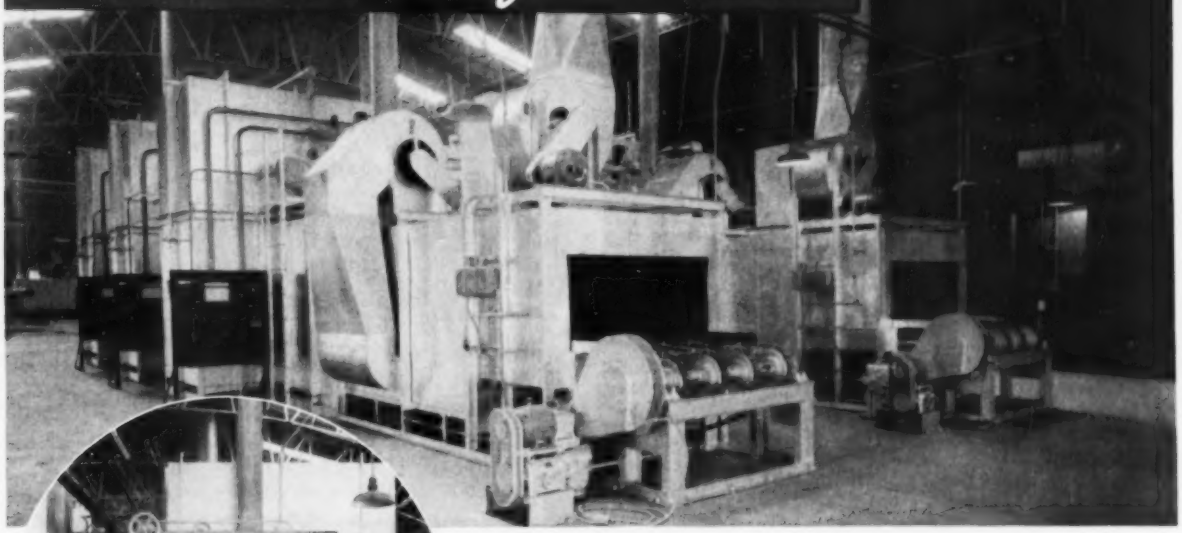
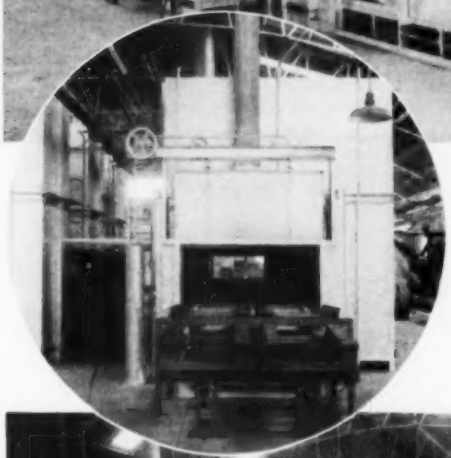
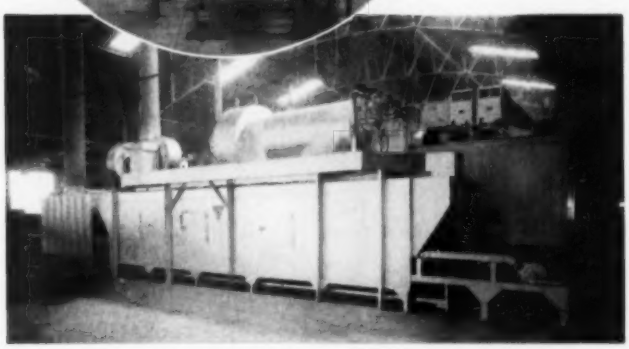
HEAT TREATING STEEL SHELL CASES REQUIRES

Guaranteed Performance







Get New Speed, Greater Economy, Higher Quality with

DESPATCH FURNACES

Modern DESPATCH Furnaces are engineered to meet specific production problems. That is why in plant after plant where DESPATCH Furnaces are on the job, production records show faster output and higher product quality at lower operating and maintenance costs.

You can count on DESPATCH Furnaces on your production line to give guaranteed performance. They are specially designed to give you faster heat transfer and uniform heat control to every part of the work chamber.

***Write • Phone • Wire* DESPATCH TODAY!**

Blueprints of layouts for various sized shell cases are available upon request. We assure you prompt delivery of any furnace you need. Write, phone or wire for blueprints and quotations today, to Dept. P.

A TRIO PROVIDING SMOOTH, UNINTERRUPTED PERFORMANCE

These pictures illustrate one of many DESPATCH production lines in operation for the heat treating of steel shell cases. Top photo shows two DESPATCH annealing furnaces working side by side. In the circle is a close-up of the entrance end to one of them. Bottom photo shows a DESPATCH stress relieving furnace. All phases of the operations are under rigid control and provide smooth, uninterrupted performance with absolute assurance of proper heat treatment in every load.

DESPATCH OVEN COMPANY

Minneapolis Office:
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4554 N. Broadway

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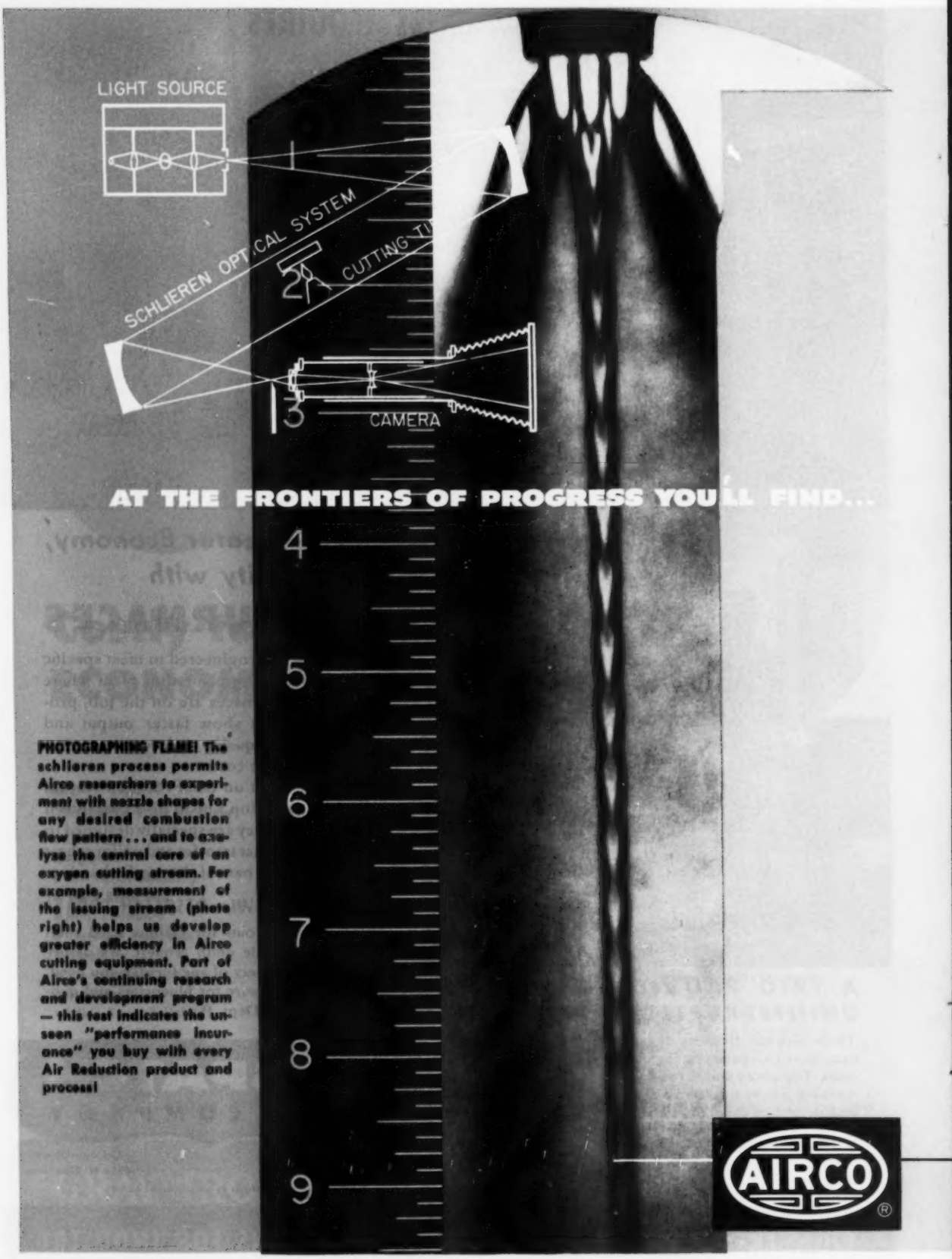
PIONEERS IN ENGINEERING HEAT APPLICATIONS FOR INDUSTRY


LIGHT SOURCE
SCHLIEREN OPTICAL SYSTEM
CUTTING
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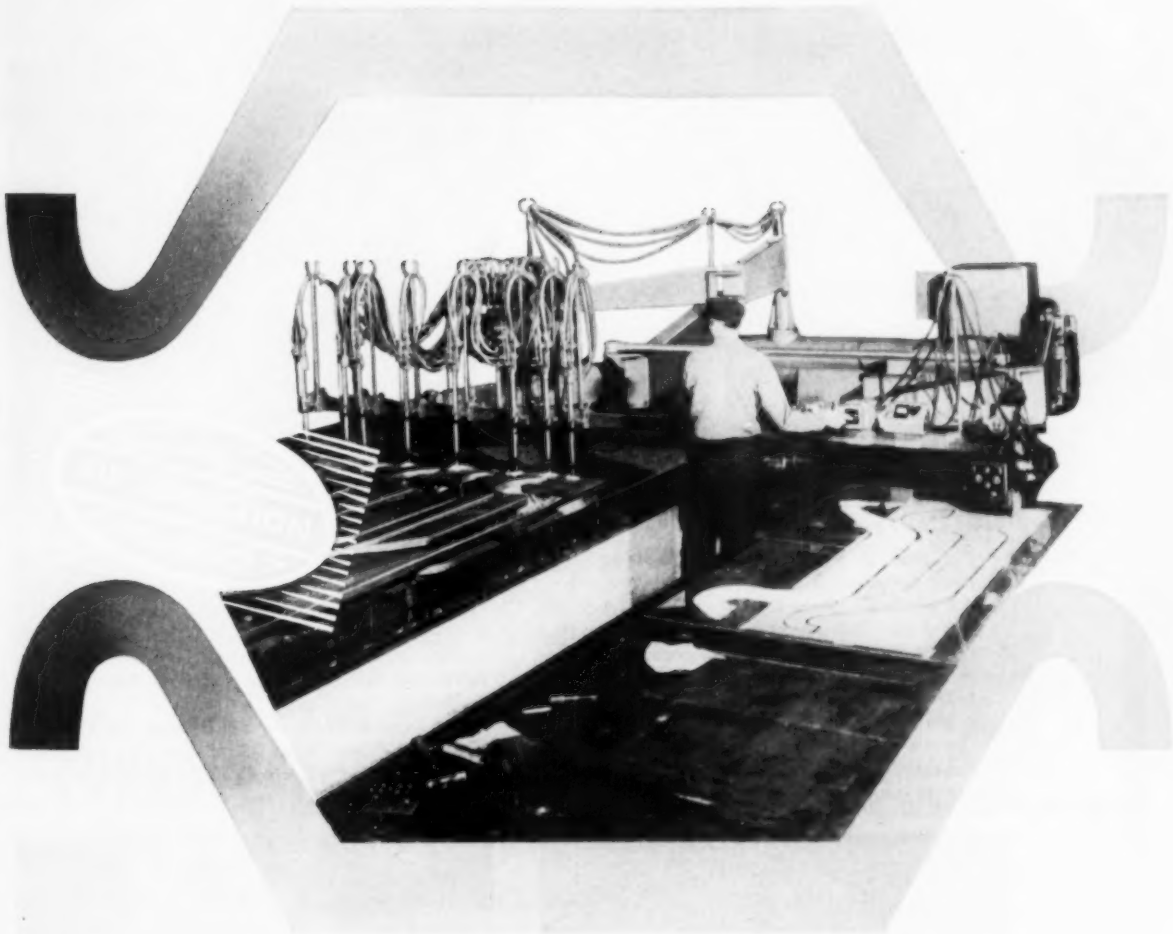
AT THE FRONTIERS OF PROGRESS YOU'LL FIND...
PHOTOGRAPHING FLAME! The schlieren process permits Airco researchers to experiment with nozzle shapes for any desired combustion flow pattern . . . and to analyze the central core of an oxygen cutting stream. For example, measurement of the issuing stream (photo right) helps us develop greater efficiency in Airco cutting equipment. Part of Airco's continuing research and development program — this test indicates the unseen "performance insurance" you buy with every Air Reduction product and process!
AIRCO
OXYGEN • ACETYLENE • INDUSTRIAL AND RARE GASES • CALCIUM CARBIDE • WELDING SUPPLIES AND ACCESSORIES

YOKES FOR AN IRON HORSE...



THE AIRCO NO. 50 TRAVOGRAPH mass produces yoke-shaped equalizer bars for locomotives . . . to a 1/16" tolerance! Torches are automatically guided by an electronic tracer following a low-cost, pen-and ink drawing . . . as four bars are cut simultaneously from 1½" mild steel, hot rolled plate. The versatile Travograph may be used for straight cutting, beveling or squaring . . . for circles up to 12 feet in diameter . . . or for straight lines of any desired length by adding extra sections of rail. Intricate shapes . . . cut to specification . . . with precision!

And remember, when you need oxygen, acetylene, other industrial or rare gases, think of Air Reduction. A nation-wide distribution system is ready to supply your needs.

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For *FAST* Foundry Floors use Lumnite* Heat-Resistant Concrete

At Silverstein & Pinsof, Inc., Chicago, workers were surprised when they returned after a one-day shutdown and found this Lumnite Heat-Resistant Concrete floor in place, ready for service.

TALK ABOUT SPEED! This tough Heat-Resistant Concrete floor was poured during a *one-day* shutdown. In service the very next day, it has taken the soaking heat of melting furnaces and the pounding of scrap boxes for 3½ years—and it's still going strong.

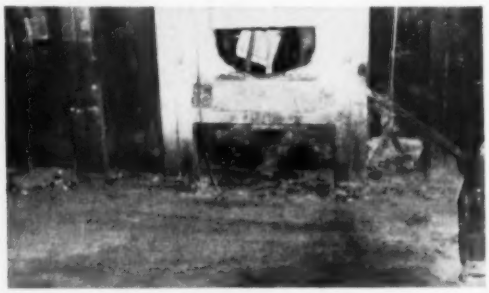
A RECORD? Far from it. You can *expect* speed with any Lumnite Concrete. It reaches service strength in 24 hours or less . . . cuts outage time on both Heat-Resistant and Refractory jobs. You can count on durability, because Lumnite Concrete withstands severe thermal shock. With suitable aggregates, it takes heat to 2600° F. And it's easily and economically poured in the shape and size needed.

Why not check now to see where you can speed construction and cut costs with Lumnite calcium-aluminate cement? It can be used for Heat-Resistant, Refractory or Insulating Concrete, depending on the aggregate. Lumnite has an enviable record of service and economy on such tough jobs as furnace car tops, door linings, arches and base pads, stack linings, and slow-cooling pits.

FOR CONVENIENCE, you may prefer to buy prepared Castable mixes. These packaged mixtures of Lumnite and selected aggregates are tailor-made to meet your specific temperature and *insulation* requirements. Add only water. They are made by refractory manufacturers and sold through their dealers.

For more information write: Lumnite Division, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

Constant pounding force of red-hot skulls being dumped hasn't hurt this Lumnite Concrete floor at Silverstein & Pinsof. Reports say floor is in good condition after 2½ years.



Lumnite Heat-Resistant Concrete worked so well for furnace room and slag dump floors that Silverstein & Pinsof is using Refractory Concrete to reline doors of melting furnaces.

**"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

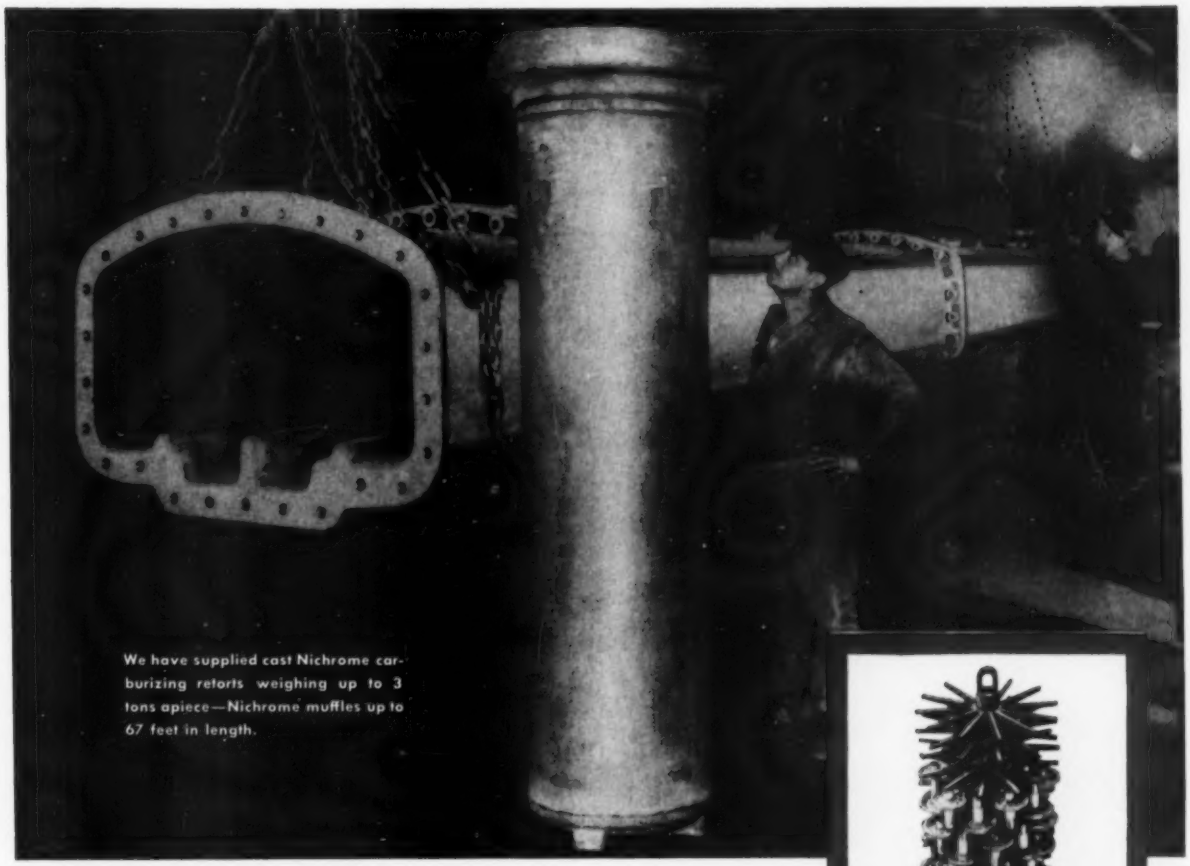
MP-L-51-R

ATLAS® **LUMNITE for INDUSTRIAL CONCRETES**

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

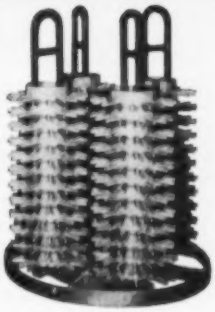
A UNIVERSAL ATLAS PRODUCT

THE THEATER GUILD ON THE AIR—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings*—NBC NETWORK



We have supplied cast Nichrome carburizing retorts weighing up to 3 tons apiece—Nichrome muffles up to 67 feet in length.

Center-post Fixture—
22" diameter—28" high



Four-stack Fixture—
40" diameter—30" high

We are specialists in

FURNACE PARTS and FIXTURES

any size and shape—but just one quality

Whether you need baskets weighing a few pounds apiece, or retorts weighing several tons per unit, we can supply dependable heat-treating equipment that stands up to the severest punishment and gives long, trouble-free service. We offer only one quality: the *best.*

Furnace parts and fixtures made of Nichrome* and Chromax*—the high *heat- and corrosion-resistant* alloys specifically developed by Driver-Harris—are unsurpassed for heat-treating applications. Both alloys assure *appreciably lower heat-hour costs.*

With our exceptional facilities for designing and manufacturing, we can meet any specifications—supply you with equipment "tailored for the job."

Nichrome and Chromax are produced only by

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HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

*T. M. REG. U. S. PAT. OFF.

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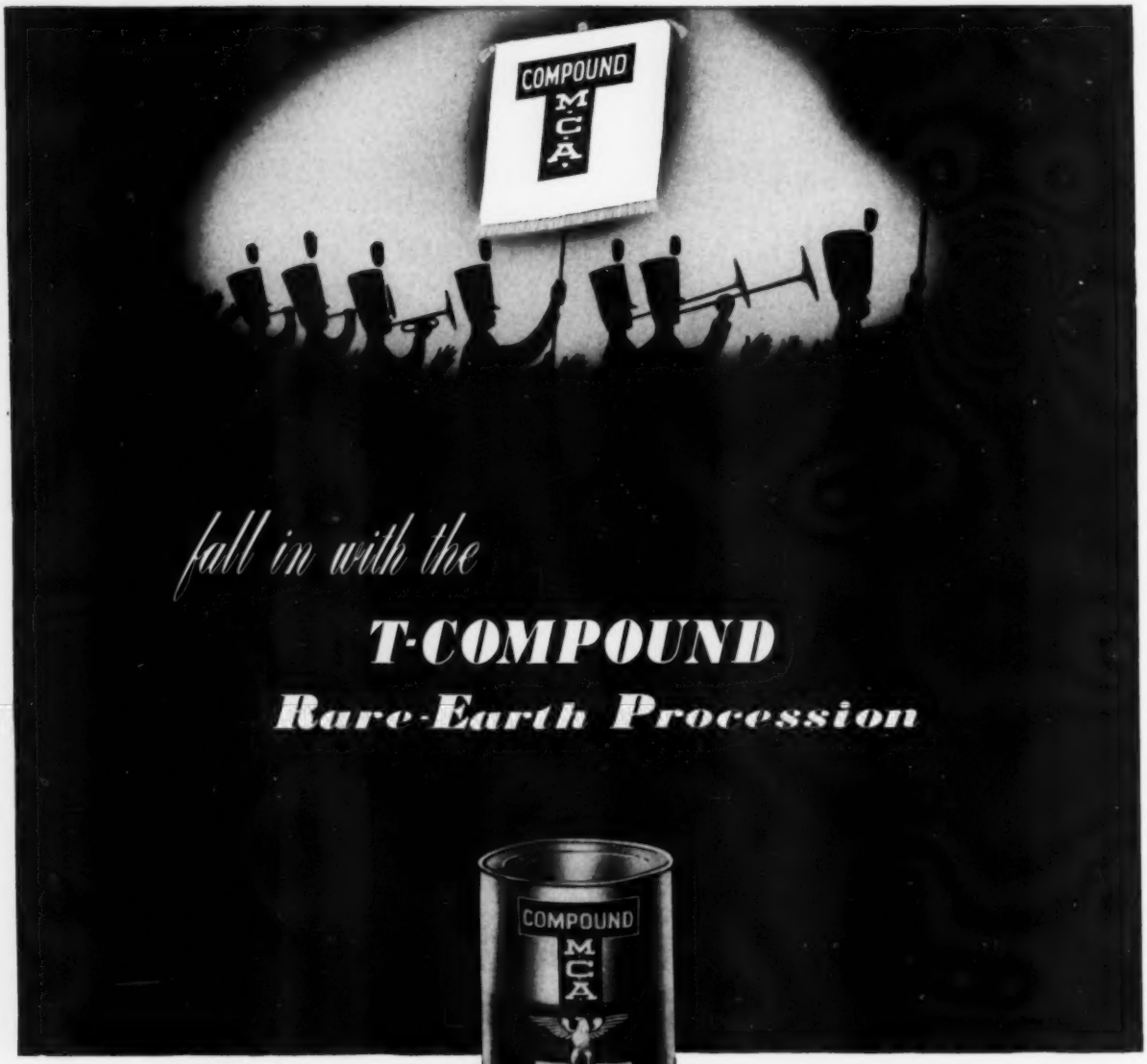

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T-COMPOUND

Rare-Earth Procession

Castings for today and tomorrow need constant improvement. A new help is now offered. Use of Rare Earth materials yields better, definitely uniform physical properties, and gives added assurance of meeting specifications.

A special product, "Rare-Met" T-Compound, developed by the Molybdenum Corporation, is most convenient and most thoroughly approved for use in both steel and nodular iron.

Having its own huge rare-earth deposits, the Molybdenum Corporation has devoted special research to these materials and can give advice on a wide variety of applications. You may wish to investigate.

As a supplier of Molybdenum, Tungsten, Boron, and other alloying materials, the Molybdenum Corporation welcomes correspondence on any requirement.

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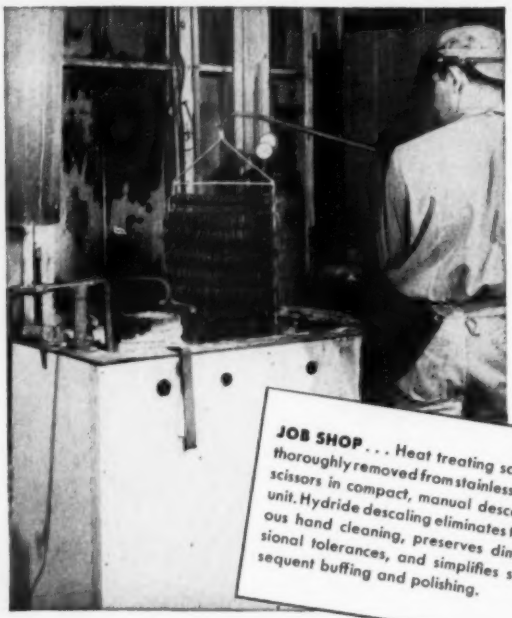
NO SECTION TOO BIG . . . NO PART TOO SMALL

STEEL MILL . . . Heavy plates of stainless steel, nickel and high nickel alloys are treated in the hydride bath for uniform removal of hot rolling and annealing scale. High speed of the descaling process increases production capacity . . . cuts costs.



JOB SHOP . . . Heat treating scale is thoroughly removed from stainless steel scissors in compact, manual descaling unit. Hydride descaling eliminates tedious hand cleaning, preserves dimensional tolerances, and simplifies subsequent buffing and polishing.

FOR THE
DU PONT SODIUM HYDRIDE DESCALING PROCESS

FROM OUNCES TO TONS! That's the capacity range of current sodium hydride installations in mills, factories and job shops of all sizes. And with each unit, the same results—speedy, uniform descaling of many different metals at a saving in time and material. Hydride descaling leaves surfaces clean and bright . . . does not attack base metal. Yet, scale is thoroughly removed from even the most intricate part by the penetrating bath action.

FOR MORE INFORMATION about the Du Pont Sodium Hydride Descaling Process, just get in touch with our nearest district or sales office or send the coupon below to: E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

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- **HIGH-SPEED OPERATION**—Descales in shortest practicable time cycle . . . can be adapted to manual, conveyorized or continuous operation.
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Wilmington 98, Delaware

Please send me more information on the Du Pont Hydride Descaling Process: advantages, applications, equipment used. I am interested in cleaning_____products.

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DU PONT
Sodium hydride process for positive descaling

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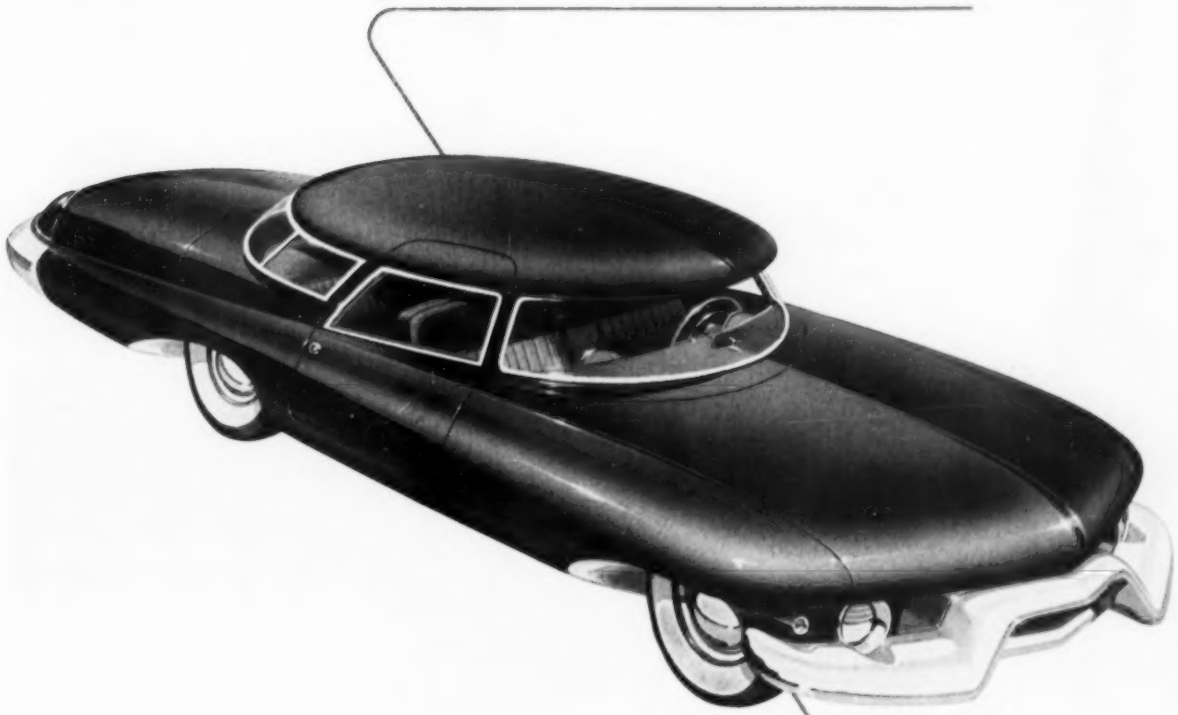
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Specify **N·A·X** HIGH-TENSILE STEEL

for Lighter Weight Longer Life with Economy



N-A-X HIGH-TENSILE, with its 50 percent greater strength than that of mild carbon steel, means that thinner sections can be used . . . resulting in lighter weight of products. Because it is an alloy steel, it possesses much greater resistance to corrosion with either painted or unpainted surfaces. It has high fatigue and impact values, at normal and sub-temperatures, with the abrasion resistance of a medium high carbon steel . . . resulting in longer life of products.

N-A-X HIGH-TENSILE has outstanding cold-forming properties, and its response to welding, by any method, is excellent. Due to its inherently fine grain and higher hardness, it can be ground and polished to a high degree of lustre at lower cost than possible with mild carbon steel.

Your product can be made lighter in weight . . . to last longer . . . and in some cases, be manufactured more economically, when made of N-A-X HIGH-TENSILE steel.

KEEP YOUR SCRAP MOVING TO YOUR DEALER

MAKES A TON OF SHEET STEEL GO FARTHER. Specify N·A·X HIGH-TENSILE STEEL ... And "MAKE YOUR PRODUCT LAST LONGER."

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division • Ecorse, Detroit 29, Michigan

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Meet the demand for Better Home Products by Specifying
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Customers demand strength, efficiency and beauty in the products for their home. These may be secured by the proper use of Revere Aluminum in your applications.
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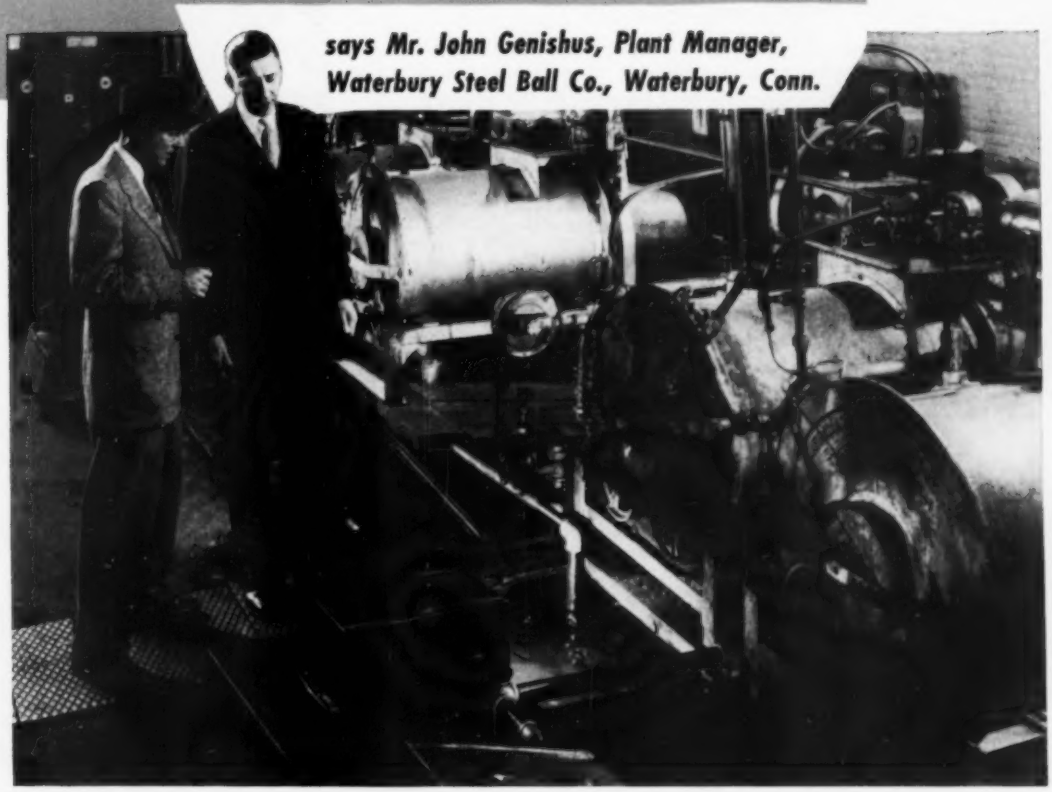
"with **GULF SUPER-QUENCH**

Rockwell C-65 is a sure thing on SAE 52100 steel balls,"



says Mr. John Genishus, Plant Manager, Waterbury Steel Ball Co., Waterbury, Conn.

"In our experience, there's nothing like Gulf Super-Quench for quenching steel balls for anti-friction bearings," says Mr. Genishus. "These parts require a uniform as-quenched hardness of at least Rockwell C-65 all the way through. Then we temper to Rockwell C-62. Metallographic examinations show we're getting a fine grain structure with Gulf Super-Quench and one which is very homogeneous. We feel that a goodly share of our success in this operation can be attributed to this fast quenching oil."

No matter what alloy steels or shapes you quench, you will gain from the greater quenching power of Gulf Super-Quench. For further details on this outstanding quenching oil, contact your nearest Gulf office.

GULF OIL CORPORATION
GULF REFINING COMPANY
PITTSBURGH 30, PENNA.

GULF SERVES INDUSTRY

Here's why it pays *to know your*

T. J. BARTKO, Honeywell Supplies Man in the Pittsburgh area, points out to Mr. E. H. Tittle, instrument department foreman at Crucible Steel, Midland, Pa., the heavy-duty construction of Brown asbestos covered thermocouple extension wire.

Your local HSM will gladly tell you about the new and improved types of extension wires for your own plant's applications, which are available for delivery from stocking points convenient to you. And he'll welcome the opportunity to explain how planned buying—the HSM way—can bring new convenience and economy to all your purchasing of pyrometer supplies. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Pa. Stocking points in Philadelphia, Cleveland, Chicago, Atlanta, Houston, Los Angeles and San Francisco.

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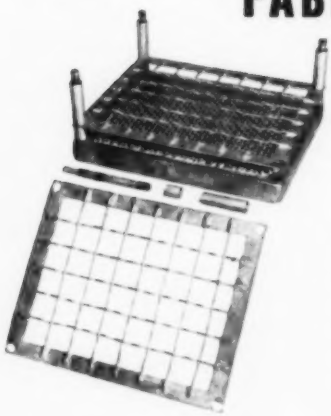
FABRICATED ALLOYS

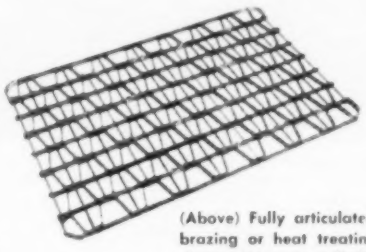


WHY FABRICATED?

All Rolock heat treating equipment is fabricated . . . not cast. Every carrier is job-engineered for the specific use and made from the correct metals and alloys for maximum resistance to all conditions of exposure, shock and abrasion. Especially successful are Rolock applications of nickel alloys . . . replacing heavy castings with durable, lighter weight fabrications. The examples shown below, while custom-built, can be adapted to your needs. We welcome your requests to solve your heat treating equipment problems.

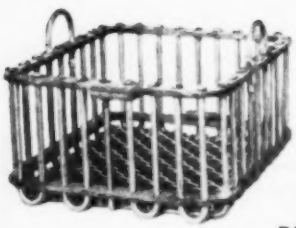
(Above) Rugged assembly for carburizing shafts in pusher furnace. Adjustable posts position fabricated alloy screens; mesh to suit work. Light weight, high pay load, long life.

(Above) Inconel basket assembly for nitriding. Only required baskets need be used for less than capacity operation . . . reducing furnace load.



(Above) Fully articulated "Serpentine" brazing or heat treating tray, retains shape. Heavy or light, any width, length, depth. Many uses at lowest hourly cost.

(Below) Inconel muffle for hardening roller bearing parts in gas furnace, with propane and cracked ammonia atmosphere. Flange faces machined for gas-tight service at 1600° F.



(Left) Alloy carburizing basket. Loose joints expand under heat. Rugged, flexible construction resists abuse.

(Right) Stainless drop-bottom pit furnace basket for quality, uniform heat treat. Saves seconds between heat and quench.

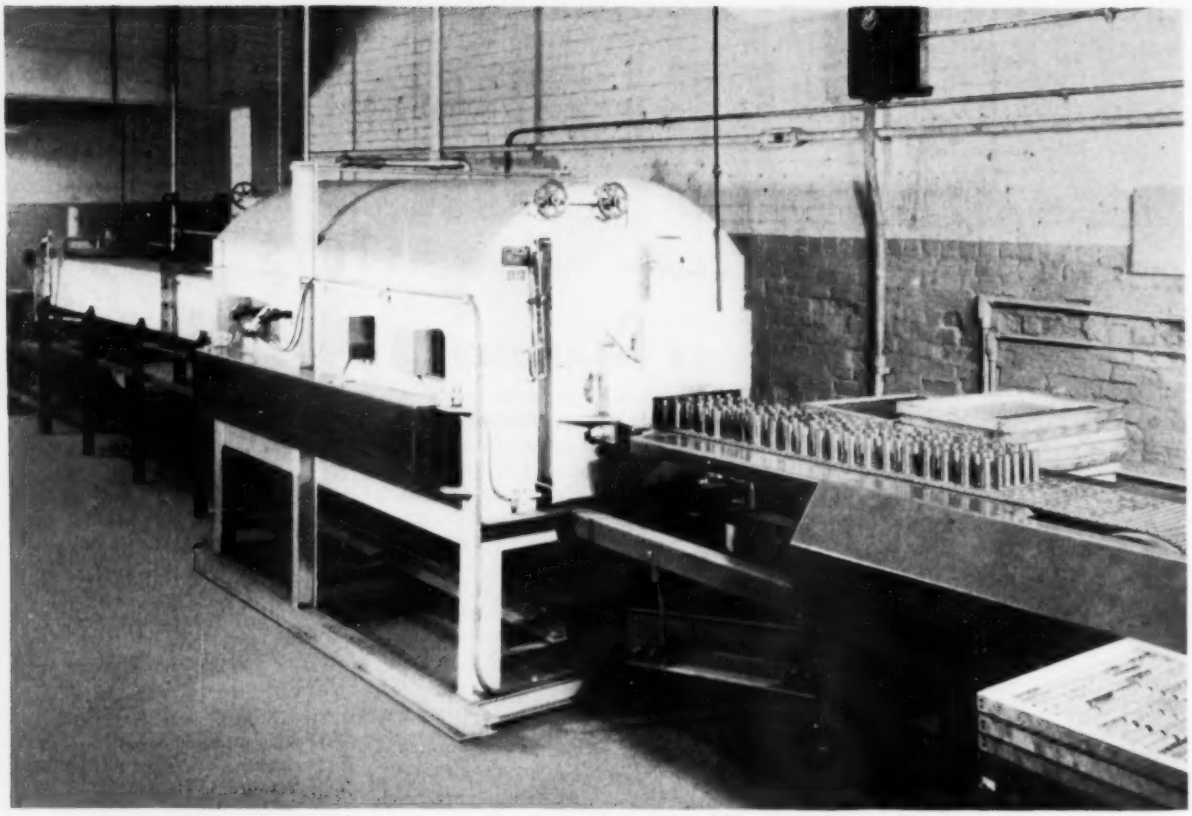
(Right) Sectional lift post carburizing fixture. Most versatile for handling variety of parts. Each loaded grid quenched separately, if desired.

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

Offices in: PHILADELPHIA, CLEVELAND, DETROIT, HOUSTON, CHICAGO, ST. LOUIS, LOS ANGELES, MINNEAPOLIS, PITTSBURGH

for better work
Easier Operation, Lower Cost

3RL53



USED FOR COPPER BRAZING of hardware parts, this electric furnace was built by American Electric Furnace Inc., Boston, Mass. for Sargent & Company, well known hardware manufacturers of New Haven, Conn. The alloy conveyor belt at right runs over Norton CRYSTOLON* hearth tile in the furnace.

More proof that Norton Special Refractories cut furnace operating costs

Here's a typical case of how Norton CRYSTOLON hearth tile pays off in low-cost, trouble-free service and greater overall furnace efficiency. And not just in one or two advantages, but in every detail essential to top performance. For example:

- This Norton CRYSTOLON hearth provides an ideal refractory bed for the conveyor belt. It exerts so little abrasive action on the belt, and its resistance to the belt's abrasive action is so high, that neither tile nor belt have required any replacement in almost three years of steady operation.
- Equally important: the great strength, high thermal conductivity and uniform heat dispersion of CRYSTOLON refractories are valuable aids to better, more economical furnace performance.
- As proved in many similar high heat applications, CRYSTOLON refractories — due to the Norton method of processing silicon carbide — *will not warp.*

Let Norton Help You

Since no single refractory combines every desired property in the highest degree, no one refractory meets every need for every user. However, Norton CRYSTOLON silicon carbide, ALUNDUM* fused alumina, MAGNORITE* fused magnesia and the sensational new FUSED STABILIZED ZIRCONIA provide a complete line of refractory compositions, shapes and cements, covering the range of applications.

Most likely this broad, varied line already covers your own requirements. If not, your Norton Refractories Engineer, backed by over 40 years of Norton pioneering and development will gladly help you to get money-saving results—with refractories engineered to your exact needs. Call him for this valuable service. Or write to NORTON COMPANY, 322 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

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Special REFRACTORIES

Making better products to make other products better

NORTON COMPANY, WORCESTER 6, MASSACHUSETTS

Metal Progress . . . . . March 1953 Vol. 63, No. 3

Published monthly; subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $2.00. Entered as second-class matter, Feb. 7, 1921, at the post office at Cleveland, under the Act of March 3, 1879 . . . The AMERICAN SOCIETY FOR METALS is not responsible for statements or opinions printed in this publication . . . Requests for change in address should include *old* address of the subscriber; missing numbers due to "change in address" cannot be replaced. Claims for nondelivered copies must be made within 60 days.

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Sure of your Alloys?

Call Ryerson and Be Sure, 8 Ways!

Like the bar in this picture, *every bar* of Ryerson alloy steel has its mark—a symbol that identifies the particular heat from which the bar was rolled. And on all but the smallest bars this heat symbol is unmistakably stamped into the steel itself.

The result: Positive heat identification, just one of eight ways that we protect you against the many slips that could occur before the alloy steel you order reaches you.

Your protection begins with careful selection of the heats to be carried in our stock. Next, analysis is verified and all Ryerson alloys are spark tested to guard against mixed steels. Then the bars are color marked and stamped to identify type and heat. Meanwhile, we test a sample of every heat for hardenability and interpret the test results for you. So, finally, when you call Ryerson for alloys, you can be SURE—sure of the steel you get and sure of what it will do.

Tested steel—racked separately by heats—is taken from stock; prepared to your specification; given a final inspection and shipped to you quickly. And with your steel (as-rolled or annealed), you receive complete test data to verify quality and guide your heat treatment.

This 8-point quality control is yours, at no extra cost, from Ryerson—and only from Ryerson. Just call your nearby Ryerson plant.

PRINCIPAL PRODUCTS IN STOCK: CARBON, ALLOY & STAINLESS STEEL—BARS, STRUCTURALS, PLATES, SHEETS, TUBING, ETC.

RYERSON STEEL

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • PHILADELPHIA • CINCINNATI • CLEVELAND • DETROIT
PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

Fig. 1 – The First Tunnel Kiln Sponge Iron Plant on This Continent at the Steel Plant of Hojalata y Lamina in Monterrey, Mexico. Loaded kiln cars on track at left each hold 84 saggers containing mixture of ore and coal

Sponge Iron

SOME INTERESTING DEVELOPMENTS in the direct reduction of iron have been taking place in the last year or two. The commercial production of sponge iron for melting stock in steelmaking has now increased from about 20,000 tons per year to about 50,000, and will reach a level of about 200,000 tons per year within the next two years. These figures take into account only the commercial production in Sweden and Mexico.

It is still true that no serious consideration can be given to commercial production of sponge iron for melting stock in most places in Canada or the United States where conventional processes are operating, and under prevailing prices of scrap, labor and raw materials in these countries. It is quite possible that, at some particular locations *in North America* north of the Mexican border, local conditions regarding labor or prices of raw materials will allow profitable production of sponge iron for a local market. For this reason the developments in Sweden and Mexico are of particular value.

A great deal of time has been spent in study of the commercial possibilities of direct reduction in North America, usually with very disappointing results, often due to the fact that direct reduction as it is known at present is a small-scale operation which has very little chance of competing with the blast furnace on the same scale of operations. The money spent on these past and present investigations might more profitably be used to produce sponge iron by one of the two commercially proven and operating small-scale processes. It is quite possible to prepare reliable production cost estimates for these processes for any location in North America. It is also possible to build plants (which are duplicates of successful operating commercial plants) using these processes, for a very low investment cost per ton-year of production. What is needed now is more and better information on the use of sponge iron for making steel. Further refinements on the methods of making sponge iron could very well wait until the benefits, both technical and financial, of using sponge iron for steelmaking in North America are clearly demonstrated. This is now being done.

The Mexican Plant – As an illustration, the steel plant of Hojalata y Lamina in Monterrey, Mexico, has now in operation the first tunnel kiln sponge iron plant on this continent. Its entire output is being melted in standard electric steel furnaces to make ordinary rimming steel for rolling into sheet. With the local costs for raw materials and labor, sponge iron is being produced cheaper than scrap can be purchased at that same location. There are no serious difficulties in making good rimming steel with a better yield than with straight scrap charge and at a lower total cost.

The process being used at Monterrey is carried on in a specially designed tunnel kiln rated at about 10,000 tons per year capacity. Lump Durango ore, sized to $+\frac{1}{4} - \frac{3}{4}$ in. and analyzing 62% iron, is charged into saggers

By P. E. CAVANAGH, Assistant Director
Department of Engineering and Metallurgy
Ontario Research Foundation, Toronto, Ont.

along with a local bituminous coal. These saggers are passed through the kiln on cars, being held 12 hr. at just over 2000° F. The resulting lump sponge iron, which is about 85% reduced on this particular cycle, is charged to the electric melting furnaces along with scrap. At present all charges contain about 30% sponge iron. As soon as possible the company plans to build three more kilns to increase the proportion of sponge iron in the charge.

An identical installation can be built in Canada for about $250,000 or an investment of approximately $30 per ton-year of production. The kiln itself costs about $150,000 in Canada.

Probably the most interesting features about the operation at Monterrey are that this is the first instance of a company in North America producing sponge iron on a commercial scale and melting it in its own steel furnaces and that the plant has been in operation since January 1952 melting between 600 and 800 tons per month of satisfactory sponge iron. The results are of particular interest to those who still believe that it is difficult or impossible to melt sponge iron to make ordinary steels and at the same time to make a profit.

Swedish Operations – Direct reduction of iron ore has long been a specialty of the Swedes. Until recently the kiln plant at Hoganas and the Wiberg furnace at Soderfors have been the world's only commercial operations. After an exhaustive study by Jernkontorets, the Swedish Ironmasters' Assoc., the conclusion was reached that sponge iron is a more satisfactory substitute for charcoal pig iron in the manufacture of steel than coke pig iron would be. The study also showed that the cost of steels made from sponge iron was lower (under Swedish conditions) than the cost of steels made from coke pig iron. Accordingly, further construction of sponge iron plants has been undertaken to replace dwindling supplies of charcoal iron.

The plant at Hoganas now produces only sponge iron for making iron powder. The plant at Soderfors is still producing sponge iron for melting in its own associated electric steelmaking furnaces to high-quality, high-alloy steels. Another Wiberg-Soderfors furnace has been built and is now operating at Sandviken. About six other Wiberg-Soderfors furnaces are either under construction in Sweden or are planned for the near future; construction of two tunnel kilns is also under way. Total production of sponge iron for melting stock in Sweden should reach 120,000 tons per year in the near future; most of this will be melted into specialty steels.

The extensive information available in Swedish publications shows how sponge iron may be used in different types of furnaces, such as acid openhearth, basic openhearth, acid and basic electric. In addition to specifying the chemical composition and physical nature of sponge iron, it is very necessary to specify also how the sponge iron must be charged and melted in the particular furnace in which it is to be used. Sponge iron is not scrap, and if it is treated in the same way as scrap in a steelmaking furnace the results are not likely to be encouraging.

As is always the case, there are a number of new direct reduction processes now under development. A few of these are further refinements of commercially proven processes. The pre-reduction of feed for electric smelting furnaces by the rich gas which comes from such furnaces falls under this classification. Development of this modification of the Wiberg-Soderfors furnace is continuing at Luleå in Sweden. The Hoganas company has also modified the kiln method so the saggers may be eliminated.

Considerable furor was created in the United States over the Madaras sponge iron process, for which some rather sweeping claims were made. Careful investigation indicates that this process does not offer any major improvements in performance over the other commercially proven processes. (See the report, dated May 4, 1951, of J. G. Thompson of the U. S. Bureau of Standards.)

The availability of cheap hydrogen as a by-product of large-scale chemical processes, notably the production of carbon black, has revived interest in hydrogen reduction of iron ore. In spite of the technical difficulties, there are some interesting theoretical advantages to be gained. The economics of the methods bring the production cost within reason, if the cost of hydrogen is 30¢ per thousand cu.ft. or less.

Costs – In all studies of new methods of direct reduction, it is very well worth-while to compare performance and costs with the Wiberg-Soderfors and the tunnel kiln processes. Particularly, the Wiberg-Soderfors process provides a reliable yardstick for energy requirements. Its heat requirement (about 7,000,000 B.t.u. per ton of metallic iron) probably represents the closest approach to the theoretical heat requirements for direct reduction that will ever be attained. Heat requirements *equal* to the Wiberg-Soderfors process should be looked

on with extreme interest; heat requirements *less* than the Wiberg-Soderfors process should be looked upon with suspicion.

Wiberg-Soderfors and the tunnel kiln complement one another very well. The investment cost for a production of about 10,000 tons per year is approximately three times as much for the former as for the latter. On the other hand, the labor requirement for the tunnel kiln process is about three times the labor requirement for the other. The choice between the two on this basis is fairly simple. Where labor is relatively cheap and electric power or reducing gas is relatively expensive, the tunnel kiln would be used. This is the situation in Mexico and in many parts of Latin America.

The tunnel kiln process is a crude operation requiring very large amounts of labor. Its major advantages are its low investment cost and the fact that the iron ore is not moved during reduction. This means that any type of ore, whether fine or lump, can be utilized and that the characteristics of the ore which determine whether it becomes sticky or breaks up seriously during reduction have no significant effect on the performance of the process. This means that a company can with confidence build a tunnel kiln and feed it with any type of ore and be sure that sponge iron will come out the other end. This is a unique feature.

The more efficient and technically advanced Wiberg-Soderfors process will give lower production cost where labor rates are high and where electric power or natural gas is cheap. The ore must either be in lump form or must be pelletized or sintered. An ore which becomes sticky during reduction or which decrepitates badly will choke the furnace.

At the recent UNESCO conference in Bogota, Colombia, during October, direct reduction methods and their possible applications in Latin America were considered. Excellent accounts of the various states of the art as carried on in the Wiberg-Soderfors furnace, in rotary kilns, in Krupp-Renn kilns, and in the tunnel kiln were presented. During this conference it was quite evident that there is a very strong feeling in some quarters in the United States that sponge iron in any form is no good. Opinions presented by those who are actually engaged in its production and use were that sponge iron, when produced at a profit and used in the proper way, is an excellent melting stock for making steel. In this connection it might be emphasized that no manufacturer of sponge iron now regards direct reduction as any threat to the blast furnace.

Possibilities in the Near Future

On the other hand, no apologies need be made for the small unit capacity furnaces now in operation. The efficiency of a smelting process should be expressed in terms of the profit returned per dollar invested. On this basis, the *size* of a unit is not important, *per se*. In the same way there is no suggestion that the coke oven is an impractical unit because production per unit is low compared to the blast furnace. The dollar efficiency of the coke oven – that is, the profit return per dollar investment – is satisfactory and therefore the unit size is satisfactory.

Adopting this view, the present size of direct reduction sponge iron furnaces such as the Wiberg-Soderfors furnace is "practical". In fact, it is fortunate that the units are of small capacity; their major field of use appears to be in small steel companies which are making electric steel. For such a company an investment in sponge iron furnaces to augment scrap supplies is not outside the realm of their own financial ability. This means that it is possible for a small company to invest in a single unit to make sponge iron to satisfy part of their needs for melting stock, and if this installation proves profitable in their locality, further units can be added.

Since sponge iron, regarded in this way, is a direct competitor with scrap, the contemplation of very large-scale production of sponge iron to eliminate the use of pig iron or scrap completely is merely a dream. This is so because any large-scale production of sponge iron in a given locality would result in the piling up of scrap supplies until scrap would be sold for a lower price than sponge iron can be produced. In areas such as Latin America where scrap is scarce, this would not happen for many years. A sponge iron process operating in a given locality might then be regarded partly as a control on scrap prices.

The recent rapid expansion of production shows that sponge iron melting stock has a definite place in the steel industry in some countries and in some locations where it can be provided at a lower cost than locally available scrap. Sponge iron will never replace either pig iron or scrap completely. However, experience with the melting of sponge iron, particularly in electric steelmaking furnaces, has shown that when advantage is taken of its special characteristics, the performance of the melting furnace may be as good or better than that obtained with straight scrap charges.

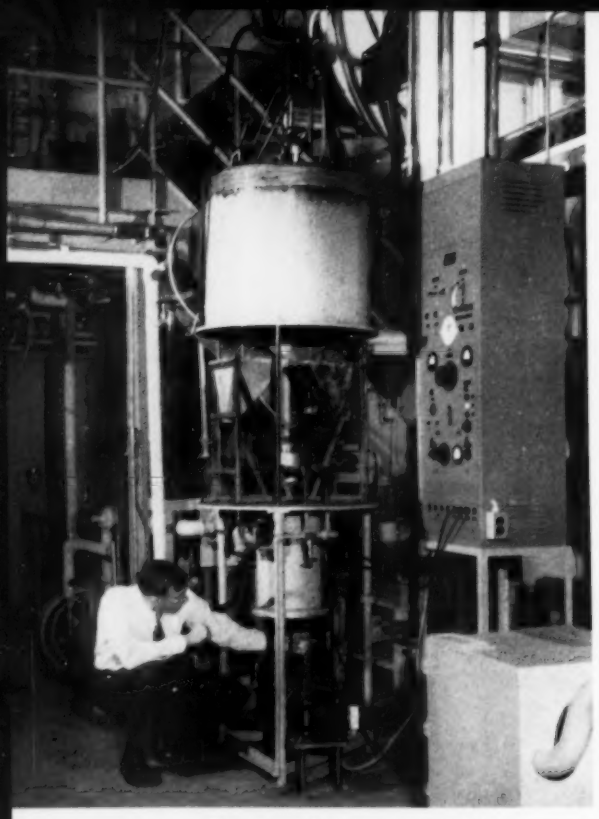


Fig. 1 – The Furnace With Upper Shell in Raised Position

By J. W. PUGH, R. L. HADLEY, and R. W. HENNIG
Research Laboratory, General Electric Co.
Schenectady, N. Y.

An Arc Furnace for Melting Refractory Metals

THE DEMAND for materials which are mechanically strong at high temperatures is prompting a number of alloy surveys in the field of higher melting point metals. The techniques for manufacturing these are considerably more difficult owing to their high melting points and greater affinities for surroundings. A relatively new kind of arc melting process which employs an inert atmosphere and a water-cooled metal crucible is currently being used successfully in several laboratories.* Such an arc furnace for consolidating refractory materials such as titanium, chromium, zirconium, and their alloys has been designed and built at the research laboratory of General Electric Co.

Figure 1 shows the furnace with the upper shell raised, and Fig. 2 represents a cross-sectional view. The furnace has an over-all height of about 7 ft., and consists of an upper and lower shell, a water-cooled, tungsten-tipped electrode, two vibratory feeders and supply hoppers, a water-cooled crucible or melting tube, and an ingot extraction rod and drive mechanism. Material to be melted is placed in the two hoppers mounted above the feeders. As the melting stock is admitted to the crucible, it is melted and stirred by a direct-current arc which is kept rotating by means of a magnetic field to insure complete melting and promote homogeneity. The movable bottom of the melting tube, on which melting starts, is made of molybdenum and provides the link between the ingot and the extraction mechanism. An argon atmosphere is provided at about 780 mm. pressure and the arc is operated at currents up to 1200 amp. at 20 volts.

The electrode is a tungsten tip 1 in. long by ½ in. diameter screwed into a copper coupling, and this in turn is silver soldered to a length of ½-in. brass tubing. A second length of smaller brass tubing is centered inside the larger tube so that cooling water flows down the center and then passes upward between the inner and outer tube to the drain. A positioning rack on top of the upper shell permits vertical manipulation of the electrode tube which passes into the shell through an insulated

*"The Melting of Molybdenum in the Vacuum Arc", by R. M. Parke and J. L. Ham, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 171, 1947, p. 416-430.

"Melting and Casting of Zirconium Metals", by W. J. Kroll and H. L. Gilbert, *Journal*, Electrochemical Society, Vol. 96, September 1949, p. 158-169.

"A Laboratory Arc Furnace for Melting Alloys Containing the Refractory Transition Metals", by G. A. Geach and D. Summers-Smith, *Metallurgia*, Vol. 42, August 1950, p. 153.

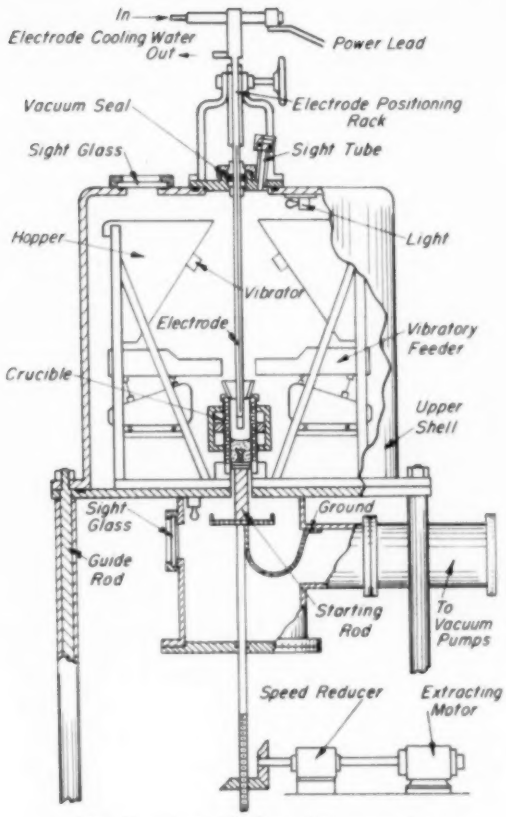


Fig. 2 – General Plan of Vacuum Arc Melting Furnace for Refractory Metals

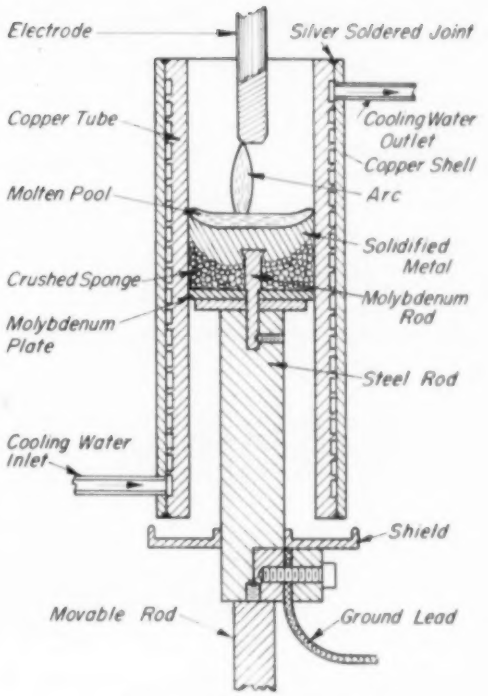


Fig. 3 – Details of the Crucible and Starting Rod

seal. A small sight tube is located near this seal to permit observation of the electrode tip and arc during melting.

Vibratory feeders can be made to supply raw materials to the crucible at controlled rates. The flow of metal is controlled by the amount of variable resistance in series with the feeders. In this way it is possible to mix two alloying ingredients in the crucible concurrent with consolidation.

Figure 3 illustrates the crucible and starting rod assembly. The crucible is 7½ in. long and has an inside diameter of 2 in. and a ¼-in. wall section. A spiral groove is turned in the inner wall and, when covered by a copper shell, this serves as a passageway for cooling water. The ingot is supported directly by a circular molybdenum plate which is positioned at the center of the crucible tube when the arc is struck and is withdrawn continuously by an extraction mechanism as melting progresses. A large steel rod links the extraction mechanism with the ingot and provides a path for the electrical circuit as illustrated. A smaller rod of polished stainless steel is fastened to this and withdrawn through an "O" ring seal in the bottom of the lower shell.

A motor and gear assembly located outside and under the lower shell operates the extraction linkage which may be lowered or elevated at will. Variable speed at constant torque is supplied to the extraction mechanism by means of a Thymotrol unit. Rate of extraction can be regulated automatically to provide a constant length of arc. This is done by means of an arc-voltage signal, since arc voltage is a function of arc length.

A magnetic field is induced inside the crucible by means of coils situated just outside the crucible. The horizontal flux components of this field react to force the arc to rotate about in a circular path on the surface of the melt. The speed of rotation is, of course, a function of the strength of the field, and control is imposed by means of a rheostat in series with the coils. The effect of this device on the product is to insure complete melting up to the side-wall of the mold and to promote homogeneity by stirring the molten region.

The products of the furnace are completely melted ingots of good quality which may be as long as 15 in. Ingots even longer than this could be made if the lower shell of the furnace were lengthened.

By O. W. SIMMONS, R. E. EDELMAN and H. MARKUS, Metallurgists
Pitman-Dunn Laboratories, Frankford Arsenal, Philadelphia

A Method of Centrifugally Casting Titanium

A GREAT DEAL of popular interest has developed in recent years in the possible substitution of titanium for the more common metals in many widely divergent applications. Acting as an incentive to this interest is the comparative availability of titanium ore, as well as the highly desirable properties possessed by titanium metal and many of its alloys. They are light, strong, ductile, corrosion resistant, and have good mechanical properties over the range of —75 to 800° F. However, titanium also has some properties which are extremely perverse and actively oppose any early widespread use. Among these are its poor machinability, high melting temperature and extreme reactivity in the molten condition.

Titanium products are now available from several commercial producers in this country, but these products are entirely in wrought form and are generally limited to plate, sheet, forgings and a small amount of tubing and wire. No commercial source of titanium castings is known, although some work is being directed toward development of casting techniques. Castings of titanium and its alloys are expected to be advantageous for intricate shapes because this metal is quite difficult to machine, particularly when it is alloyed.

Titanium castings are not being made at the present time for several reasons. The most important of these is that none of the present methods of melting provides a contaminant-free, molten bath large enough for pouring or casting. Titanium melts at a high temperature, 3150° F., and in the molten condition reacts with just about everything it contacts. Furthermore, many of these products of reaction have considerable effect on the properties of the titanium alloys containing them. At the present time, no known refractory will resist attack by molten titanium. Graphite crucibles have been used, but considerable carbon is always introduced into the metal by this procedure. High carbon, 0.5 to 1.0%, is undesirable in cast or welded titanium because large dendrites of brittle titanium carbide are formed in the titanium matrix.

In casting small quantities of titanium, some of these disadvantages are overcome. Although titanium does have a high melting point, only a slight superheat is required to impart excellent fluidity to both titanium and its alloys. Thus, when only a small quantity of metal is melted, casting may be carried out as soon as sufficient molten metal is obtained without the necessity of superheating. These factors permit a mold to be filled very rapidly at a relatively low temperature. Small castings, particularly those with thin sections, solidify in a short time so that the amount of reaction between the molten metal and the mold is further minimized. These considerations greatly enhance the possibility of casting titanium in small quantities.

During work on development of a casting method for titanium and its alloys, an induction furnace was designed and built which permitted the casting of small articles of titanium using centrifugal force to transfer the metal into the mold. This furnace used a graphite crucible for melting the titanium, but the melting cycle was sufficiently short because of the small quantity of metal; consequently, carbon pickup by the titanium did not become excessive. Furthermore, casting was carried out un-

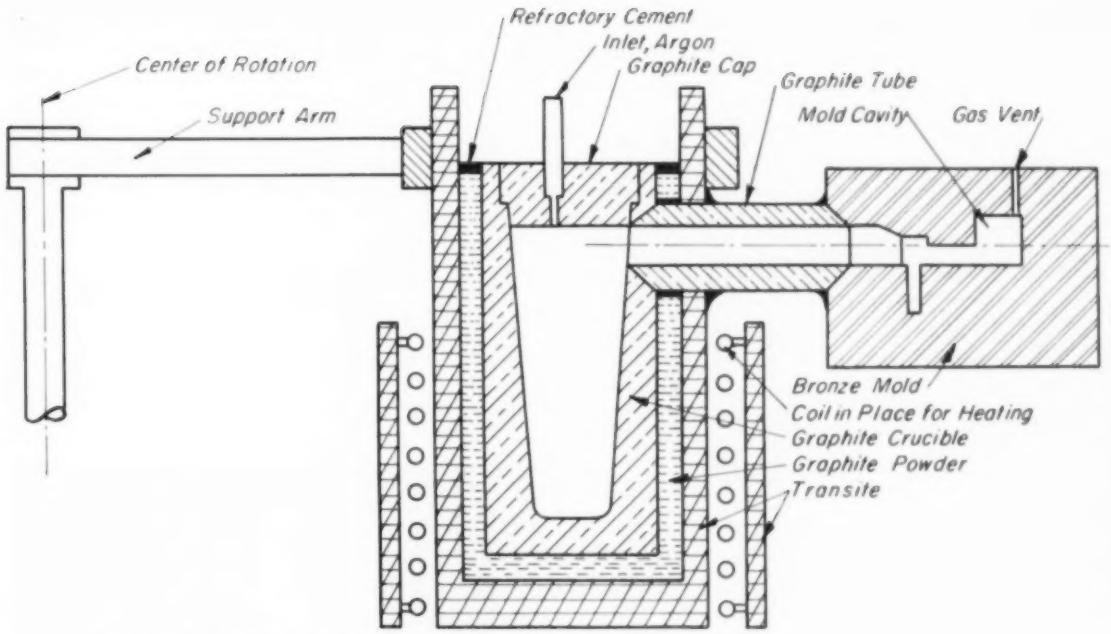


Fig. 1 – Induction Melting and Centrifugal Casting Assembly for Titanium (About Half Actual Size)

der an atmosphere of purified argon or some other suitable inert gas so that contamination of the metal by oxygen or nitrogen from the air was kept at a minimum.

The furnace used had a total capacity of about 3 oz. and is shown in cross section in Fig. 1. This furnace incorporated a transite shell and a replaceable crucible of graphite held in place with refractory cement and insulated from the transite with graphite powder. A machined graphite plug served as the cover to exclude the oxygen and nitrogen of the atmosphere, and argon gas was introduced through this cover. A graphite tube, passing through the transite, provided passage for the molten metal from the crucible to the mold. The split-type mold was prepared by precision casting methods and consisted of two blocks of bronze clamped together. The furnace and the bronze mold were clamped into a suitable support so that the connections between the various components were adequately gastight without luting. The induction coil was made sufficiently large so that it could be retracted from the crucible assembly when the centrifuging operation took place. As shown in the sketch, the entire assembly was mounted on the arm of a centrifuge so that the molten metal could be transferred from the crucible to the mold without atmospheric contamination.

A typical heat was made in this furnace as follows: Chunks of titanium metal weighing 3 oz. were placed in the bottom of the crucible. These chunks were less than ½ in. in size and were prepared from titanium sponge previously melted to remove volatile magnesium and magnesium chloride. These volatile materials would form dross in the mold if permitted to enter the melt. The graphite cap was fitted into the crucible, and the graphite connecting tube and the bronze mold were clamped into the support. Obviously this assembly could not be evacuated prior to introduction of a protective atmosphere, but adequate purging of the air was accomplished by flushing argon gas through the assembly for about 20 min. before melting. Tank argon of 99.92% purity was used for this purpose at a flow rate of approximately 5 cu.ft. per hr.

The argon was introduced into the crucible, passed through the connecting tube into the mold, and out the gas vent in the rear of the mold, thereby purging the whole assembly. The argon was conducted from the tank through a rotating joint mounted on the axis of rotation so that the argon flow was maintained even during the centrifuging operation. When the melting chamber was completely purged, high-frequency power was applied to the coil around the crucible.

A motor-generator operating at 9600 cycles and delivering 100 kw. was used as the power source. Power was introduced at short, regular

intervals to permit equalization of the temperature between the crucible and the charge. More specifically, five successive heating periods of 1 min. each, separated by 1-min. soaking periods, were used in melting the metal for the casting shown in Fig. 2. Fifteen kilowatts of power at 325 volts was applied during each of the heating periods. After the last heating period there was a pause of 30 sec. to retract the induction coil before the centrifuge was rotated. Centrifuging was carried out at 300 r.p.m., with the mold 12 in. distant from the center of rotation. During the melting cycle the graphite connecting tube reached a temperature of 1000° F. while the mold temperature was raised to approximately 250° F. by conduction from the crucible.

Several initial runs were made with stationary dummy setups to establish the melting cycle before actual casting was attempted. The first casting obtained was a small cocking lever (Fig. 2). This casting weighed 0.7 oz., and the total amount of metal melted was just under 3 oz. Most of the excess metal remained in the graphite connecting tube or in the crucible as a skull.

The metal mold was used without a coating, and the consequent chilling action on the cast metal caused minute surface defects and cold shuts that might be eliminated in future work by the use of suitable mold coatings. However, the mold surfaces were not attacked nor eroded by the titanium.

Fig. 3 – Cross Section of Sprue Adjacent to the Casting. Unetched. 100 ×

Good dimensional tolerance was obtained by this die-casting technique, which permits the massive metal mold to remain cool and retain its shape and size during the entire cooling cycle of the casting. Most titanium alloys would have sufficient hot malleability to permit casting under these conditions, wherein the casting must conform to the configuration of the mold during cooling without injury to the mold or to the casting. This simply shaped casting was formed in a split mold consisting of two beryllium-copper blocks. A casting of much more complicated shape may be made by resorting to a mold containing cores of expendable inserts.

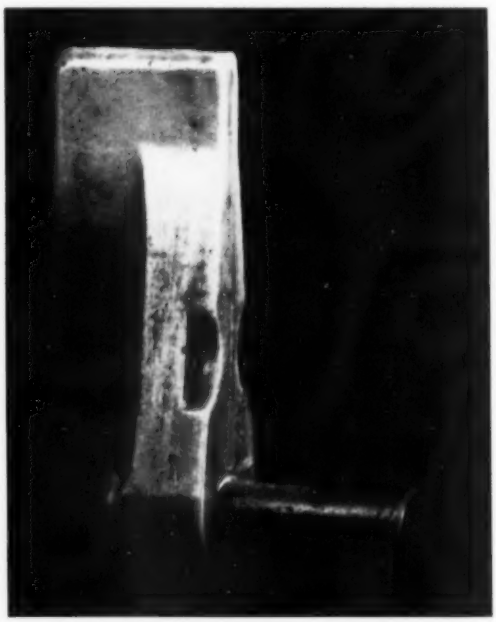


Fig. 2 – Cocking Lever Centrifugally Cast of Titanium. 3.5 ×

The casting produced in this apparatus had a carbon content of 0.35% and a Brinell hardness of 207 as determined on the sprue adjacent to the casting. The microstructure of this section of the sprue consisted of alpha matrix containing stringers of carbide (Fig. 3).

Obviously, the casting technique herein described is a laboratory method, but it demonstrates the practicality of casting titanium by means of centrifugal methods into permanent metal molds.

The work described was carried out at the Pitman-Dunn Laboratories Department, Frankford Arsenal, Philadelphia, under the auspices of the Office, Chief of Ordnance.

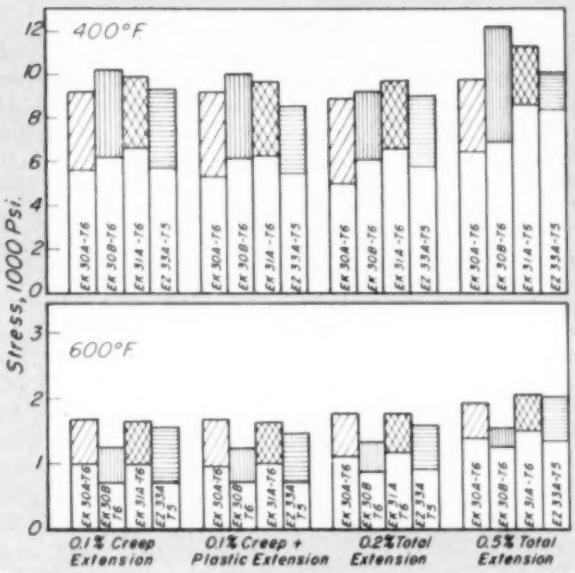


Fig. 1 – Range of 100-Hr. Creep Limits of Some Mg-RE-Zr Alloys for Bars Cut From Production Castings

By F. P. STRIETER, Magnesium Department
Dow Chemical Co., Midland, Mich.

Magnesium Casting Alloys Containing Zirconium

A CONSIDERABLE amount of information has been published in the technical literature during the past 15 years or so regarding magnesium alloys in which zirconium is one of the alloying constituents. While the early investigators were concerned with these alloys in relatively general terms, the work that has been done during the past five years has been aimed almost entirely at the aircraft industry.

Zirconium is primarily useful as an alloy constituent because it possesses a grain-refining ability, making it possible to cast alloys which otherwise would be very difficult to handle in the foundry. This grain-refining action also improves the ductility and toughness of the magnesium alloys at both room and slightly elevated temperatures.

Three different alloy systems have been commercially developed which utilize zirconium: magnesium-RE*-zirconium, magnesium-thorium-zirconium, and magnesium-zinc-zirconium. It is the purpose of this article to review briefly the properties and characteristics of the major alloys in these systems, and also to review some of the methods which have been used to alloy zirconium to magnesium.

Alloys Containing the Rare Earth Metals – Of these three alloy systems, the Mg-RE-Zr group has enjoyed the most extensive use in this country in the production of sand castings. Both the Mg-RE and the Mg-Zr alloys were initially developed by investigators in Germany prior to World War II. They reported the excellent grain-refining action of the zirconium and also the good mechanical properties of the Mg-RE alloys at elevated temperatures. In 1943, Sauerwald, in abandoned U. S. patent applications No. 369,749 and 369,824 (published June 15, 1943) disclosed a series of alloys including those containing Mg-RE-Zr, Mg-Zn-RE-Zr and Mg-Th-Zr. In 1947 Murphy and

*RE refers to rare earth metals and unless otherwise stated means mischmetal. Strictly speaking, the term "rare earth" refers to the oxide of the "rare earth metal" before it is refined to metallic form. In common usage, however, the word "metal" is frequently omitted, and in this article "rare earth" will be used to indicate the metal rather than its oxide.

Table I – Short-Time, High-Temperature Tensile Tests

Alloy	Test Temperature	Tensile Strength	Yield	Elongation
EK30A-T6	70° F.	17,500 psi.	13,300 psi.	1.0%
	400	16,000	11,000	7.5
	600	11,400	6,600	39
EK30B-T6	70	21,700	16,000	1.5
	400	19,200	13,400	5
	600	12,600	8,200	40
EK31A-T6	70	22,100	15,300	3.5
	400	16,700	12,200	12
	600	11,200	7,100	51
EZ33A-T5	70	19,800	14,300	2.5
	400	18,000	9,800	14
	600	11,300	6,700	44

Table II – Composition of Mischmetal and Other Rare Earths

Form	Total RE	Composition						
		Ce	La*	Nd	Pr	Th	Fe	Si
Mischmetal	97.8%	50.6%	22.6%	18.2%	6.4%	nil	0.59%	0.16%
Low-cerium mischmetal	98.5	3.5	43	38	14	–	–	–
Cerium-free mischmetal	94.5	0.2	46.0	35.2	12.2	0.9	3.24	0.20
Didymium	89.8	0.8	8.8	72.3	7.9	nil	7.05	0.56

*By difference

Payne reported in *Journal*, Institute of Metals (Vol. 73), the good combination of high-temperature properties when the two ingredients (rare earth and zirconium) were added to magnesium to form the alloy containing about 3% mischmetal and 0.5% zirconium.

Alloys of this type generally contain about 3% rare earth with varying amounts of zirconium. Zinc is also added to one of the alloys, to approximately the 3% level. These alloys, in either the heat treated and aged or in the as-cast and aged condition, are finding important application in the jet engine field because of their good resistance to creep at elevated temperatures, as shown in Fig. 1 on the preceding page, which shows the results of 100-hr. creep tests on bars cut from production castings of several compositions.

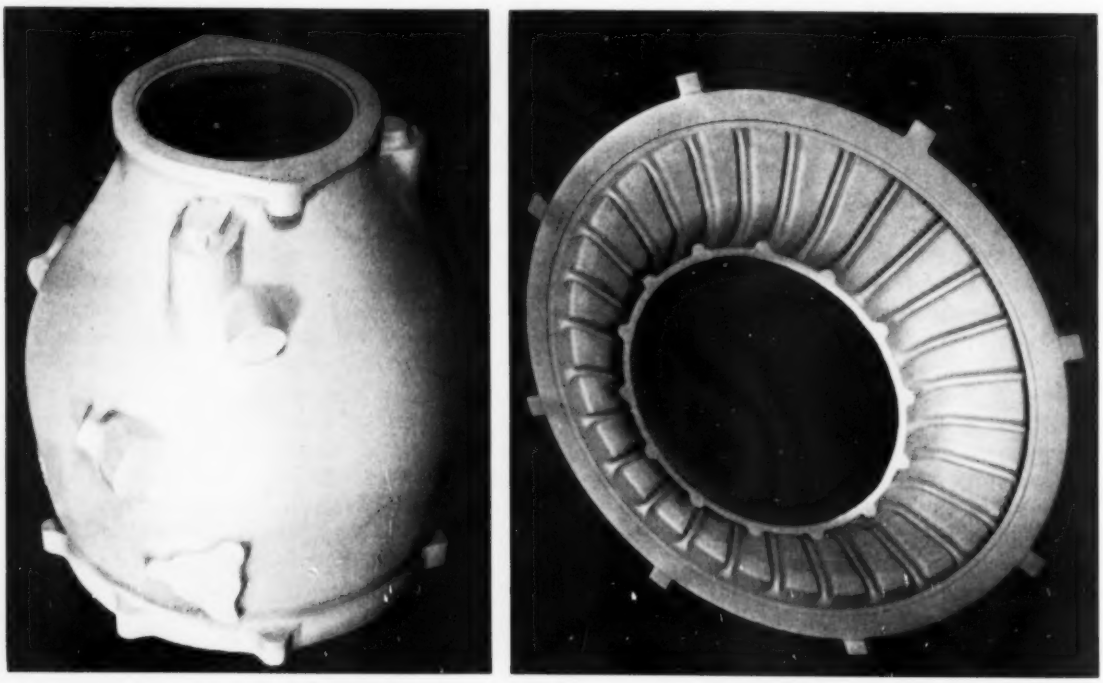


Fig. 2 – Typical Jet Aircraft Engine Castings of Mg-RE-Zr Alloys Vary in Size and Complexity. These shown are about 12 in. in diameter (left) and over 3 ft. in diameter (right)

Table III – Tensile and Creep Properties of Mg-3RE Alloys

RE Used	Temperature	Tensile Properties			100 Hr. Creep Strength		
		Tensile Strength	Yield	Elongation	0.1% Creep	0.2% Total Extension	0.5% Total Extension
Mischmetal	70° F.	20,000 psi.	12,000 psi.	1%	–	–	–
	400	17,000	12,000	5	10,000 psi.	8,400 psi.	10,200 psi.
	600	14,000	9,000	24	2,200	2,500	2,800
Ce-Free	70	23,000	15,000	2	–	–	–
Mischmetal	400	23,000	13,000	14	11,800	9,600	12,700
	600	15,000	10,000	41	1,400	1,700	2,100
Didymium	70	30,000	20,000	3	–	–	–
	400	26,000	18,000	11	13,200	10,000	14,500
	600	16,000	13,000	30	1,000	1,400	1,700
Mischmetal	70	25,000	18,000	3	–	–	–
plus 0.5% Zr	400	21,000	16,000	13	8,800	8,000	11,200
	600	13,000	9,000	52	1,300	1,500	1,700
Ce-Free	70	28,000	19,000	2	–	–	–
Mischmetal	400	25,000	17,000	11	9,400	8,700	11,200
plus 0.5% Zr	600	13,000	9,000	58	1,200	1,300	1,500
Didymium	70	40,000	23,000	7	–	–	–
plus 0.5% Zr	400	30,000	20,000	12	11,200	9,200	15,000
	600	15,000	12,000	50	1,200	1,400	1,600

Nominal compositions for proposed A.S.T.M. designations are as follows:

	RE*	Zr	Zn
EK30A	3.0%	0.25%	–
EK30B	3.0†	0.25	–
EK31A	3.0	0.6	–
EZ33A	3.0	0.6	3.0

*Rare earth (mischmetal) unless otherwise stated.
†Low-cerium mischmetal.

Table I contains average mechanical properties of bars cut from production castings, tested at temperatures noted. Figure 1 gives the creep limits. Prior heat treatments are as follows: T6 is 18 hr. at 1050° F., air cool to room temperature, 16 hr. at 400° F. T5 is an aging treatment of 12 hr. at 350° F. (The mechanical properties are from data reported by K. E. Nelson and F. P. Strieter in the *Transactions* of the American Foundrymen's Society, Vol. 59, 1951.) Castings shown in Fig. 2 are typical.

The type of rare earth commonly used is mischmetal, which contains the rare earth constituents in approximately the same ratio as they occur in monazite sand, the ore from which they are obtained. Table II shows the percentages of the individual rare earths which are generally present in mischmetal and in the low-cerium mischmetal used in alloy EK30B.

The effectiveness of some of the individual rare earths in magnesium alloys and also the value of certain combinations of these elements have been studied by T. E. Leontis (*Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 185, 1949). Table II also lists two of the compositions which he has investigated, and Table III gives the mechanical properties of separately cast test bars of these special alloys. These tests were conducted on Mg-RE alloys having no zirconium. In addition to these alloys, others containing zirconium with the special combinations of rare earths have been studied and are reported by T. E. Leontis in a paper submitted to the American Institute of Mining and Metallurgical Engineers. These results are likewise reported in Table III.

While this information would indicate that alloys containing didymium or cerium-free

Table IV – Composition and Heat Treatment of Some Mg-Th-Zr Alloys

Proposed A.S.T.M. Designation	Composition			Heat Treatment	
	Th	Zr, Acid Soluble	Zr, Acid Insoluble	Solution Treatment	Precipitation Treatment
K1	0%	0.69%	0.03%	1050° F., 2 hr.	400° F., 16 hr.
HK11	0.93	0.82	0.08	same	same
HK21	1.84	0.82	0.12	same	same
HK31	3.34	0.94	0.12	same	same
HK61	6.05	0.94	0.09	1050° F., 16 hr.	same
HK101	10.30	0.98	0.16	1050° F., 24 hr.	same
HK201	19.70	1.01	0.15	same	same

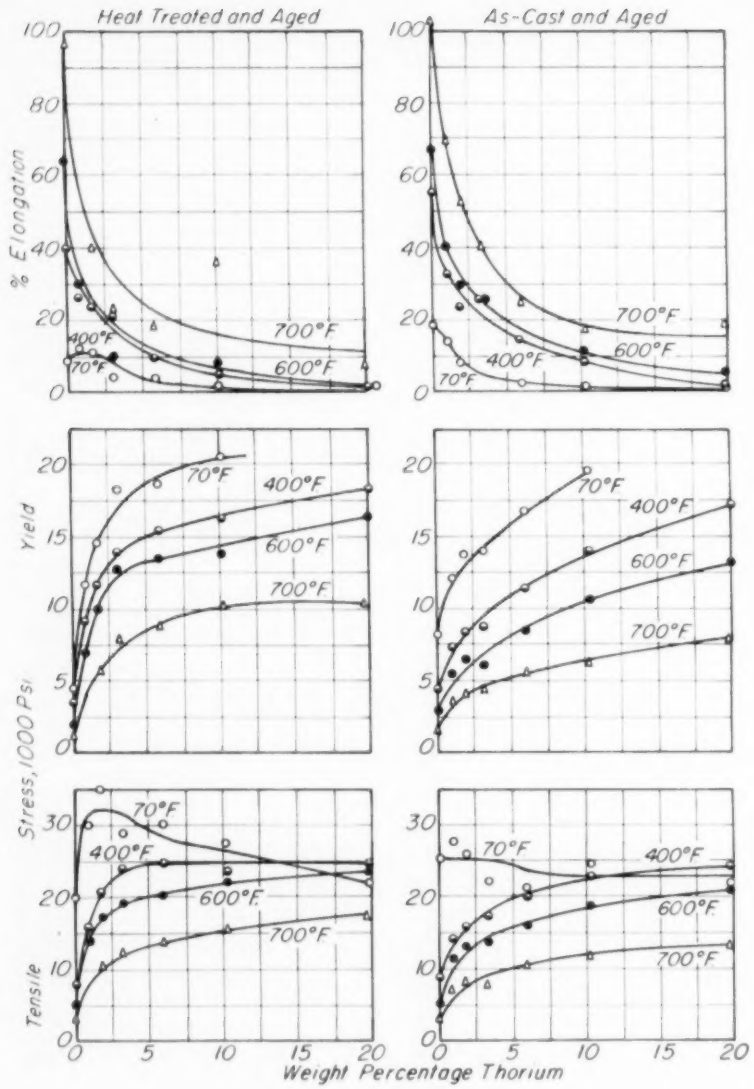


Fig. 3 – Tensile Properties of Mg-Th-Zr Alloys Containing Maximum Soluble Zr Content for Both the Heat Treated and Aged, and the As-Cast and Aged Conditions

mischmetal possess somewhat superior properties up to 400° F. over regular mischmetal-containing alloys, there has been no extensive commercial use to date of either of them. This is due partly to the lack of a commercial process for producing the alloys and partly to the fact that the Mg-Th-Zr alloys offer more promise when alloys better than those obtained with regular mischmetal are needed, especially at temperatures greater than 400° F. While all of the property data listed above are taken from published work by American investigators, the results are in substantial agreement with those reported concurrently by English and Dutch investigators. (See Footnotes 1 through 4.)

The Mg-RE-Zr and Mg-RE-Zn-Zr alloys are essentially equal to each other in castability characteristics, and they are inferior in this respect to the conventional Mg-Al-Zn alloys. They have a greater tendency toward oxidation, both in the crucible and during the filling of the mold cavity. Thus, greater care is required in handling the molten metal to obtain satisfactory castings. However, under most conditions they are free from microporosity and in this respect they are superior to some of the Mg-Al-Zn alloys. The Mg-RE family of alloys has a different solid shrinkage characteristic from the Mg-Al alloys and, therefore, requires a larger value for pattern shrinkage.

One may draw several conclusions from the study of alloys in the Mg-RE-Zr system:

1. These alloys possess very good tensile and creep properties at 400° F. and acceptably good properties for many applications at temperatures as high as 600° F.

2. The addition of zirconium is beneficial in reducing grain size and increasing the toughness of these alloys. The first 0.1% Zr is sufficiently beneficial in this respect to render the alloy castable; additional Zr – up to the solubility limit – imparts only a small increment to room-temperature toughness.

3. The addition of zinc to the alloy has essentially no effect on the over-all mechanical properties. It reduces the pattern shrinkage value somewhat and may (according to some

[1]"Outstanding Properties of the Magnesium-Zirconium Alloys", by C. J. P. Ball, *Metallurgia*, Vol. 35, 1947, p. 125, 211.

[2]"Mg-Zr Casting Alloys Attain High Strength-Weight Ratios", by H. J. Millward, *American Foundryman*, Vol. 20, September 1951, p. 44.

[3]"How to Handle Magnesium-Zirconium Casting Alloys", by L. J. G. van Ewyk, *Modern Metals*, Vol. 7, 1951, p. 48.

[4]"Some Recent Developments in Magnesium Alloys", by R. G. Wilkinson, *Metallurgia*, Vol. 41, 1949, p. 91.

investigators) improve the castability slightly.

4. The use of certain mixtures of rare earths instead of mischmetal improves the tensile and creep properties without affecting the casting characteristics or the pattern shrinkage.

5. A solution heat treatment prior to aging of the ternary Mg-RE-Zr alloys improves ductility at room temperature, but does not have any significant effect on the mechanical properties at elevated temperature.

ALLOYS CONTAINING THORIUM

A study of the magnesium-thorium alloys has been made over a period of several years by F. Sauerwald (U. S. Patent applications No. 369,749 and 369,824, and *Zeitschrift für Anorganische Chemie*, Vol. 258, 1949, p. 296), J. C. McDonald (*Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 143, 1941, p. 179), and by T. E. Leontis (*Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 194, 1952, p. 287). These alloys exhibit good mechanical properties at elevated temperature; in fact, the properties are significantly superior to those of the Mg-RE type. The addition of zirconium to this alloy system produces a fine grain structure and also materially increases the strength properties.

To date, the published literature reports properties only of separately cast test bars of alloys containing thorium. Leontis[5] reports tensile and creep properties of Mg-Th-Zr alloys as a function of thorium content, and these data are shown in Fig. 3 and 4 for the compositions and heat treatments listed in Table IV. From this information it can be seen that a solution heat treatment prior to the artificial aging produces a definite improvement in the tensile and creep properties. By comparing these data with those listed in Tables I and III and Fig. 1 for the Mg-RE alloys, it can be seen

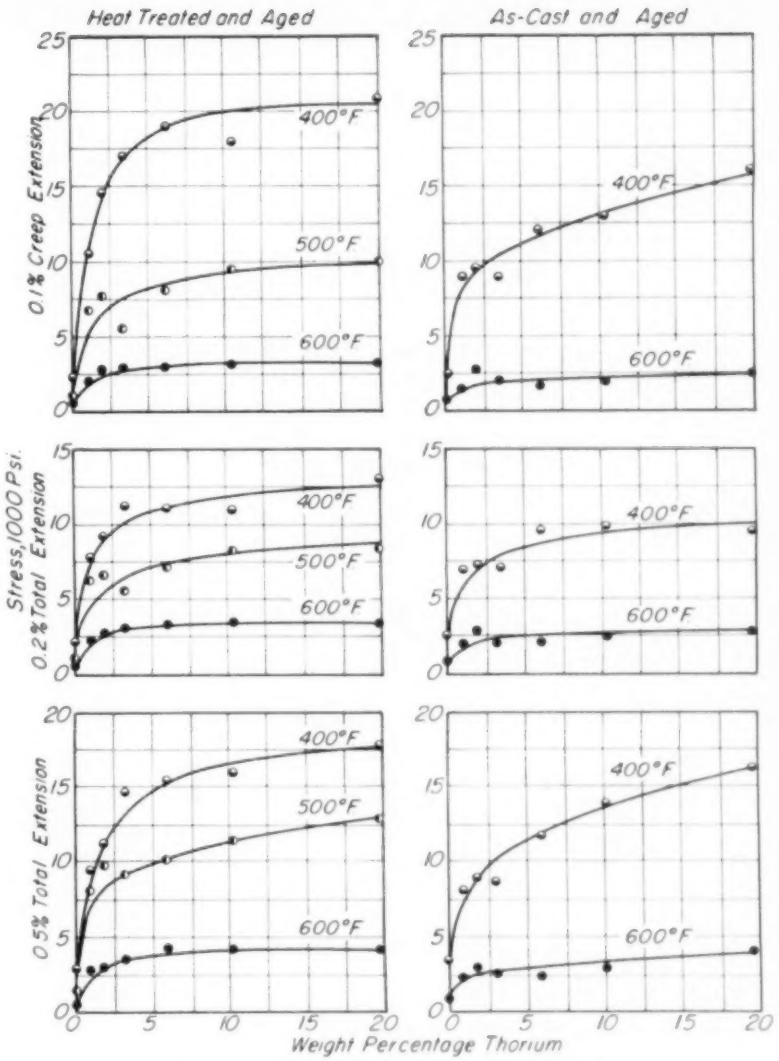


Fig. 4 – 100-Hr. Creep Limits of Sand-Cast Mg-Th-Zr Alloys in Both the Heat Treated and Aged, and As-Cast and Aged Conditions

that the addition of thorium results in superior load-carrying ability. The thorium alloys possess definite advantages over the rare earth alloys at 400 to 600° F., and they possess a degree of usefulness at 700° F., a temperature at which the rare earth alloys would generally not be considered for use.

A further study of the property data for Mg-Th-Zr and Mg-RE-Zr alloys brings forth the following point. An alloy designated HK31A (Mg + 3% Th + 0.7% Zr, according

[5]"Effect of Zirconium on Magnesium-Thorium and Magnesium-Thorium-Cerium Alloys", by T. E. Leontis, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 194, 1952, p. 633.

The Mg-Zn-Zr Alloys

to the A.S.T.M. system of nomenclature) and EK31D (didymium) are both superior to EK31A (mischmetal). The superiority of HK31A is primarily in its creep strength at elevated temperatures; with EK31D the superiority is more in the tensile than in the creep properties. This leads one to the conclusion that in those applications where creep is the important factor, such as in present jet engine applications, HK31A is the alloy to use when an improvement over alloy EK31A seems to be required.

Work has progressed to the point where sample castings of jet engine parts have been made of HK31A-T6, and these are currently being tested in aircraft. It is anticipated that some results of the tests will be known in the not-too-distant future. In the course of manufacturing these castings it was determined that this alloy is about equal in castability to the Mg-RE-Zr alloys. Its pattern shrinkage is also of the same order of magnitude.

Another alloy containing about 2½% zinc in addition to the magnesium, 3% thorium, and 0.7% zirconium has been announced recently by the U. S. Patent Office. It is U. S. Patent No. 2,604,396.

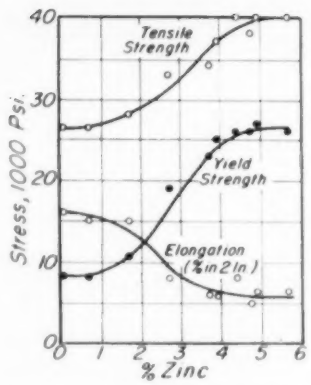


Fig. 5 – Effect of Zinc on Tensile Properties of Mg-Zn-Zr Alloys in the T5 Condition

Alloys Containing Zinc – The alloys of the magnesium-zinc-zirconium system have aroused some controversy in this country with regard to their serviceability. As an extrusion alloy a composition[6] designated ZK60A containing nominally 6% Zn and 0.6% Zr has enjoyed good commercial use in the aircraft industry in this country. Well over one million pounds of extrusions made from alloy ZK60A have been sold since about 1945.

British investigators[1, 2, 4] have studied the properties of sand-cast Mg-5 Zn-Zr alloys, and report that many prototype castings have been made in England from it. Canadian research[7] has shown that ZK61A alloy (Mg + 6% Zn + 0.7% Zr) is a good casting composition and it has been used commercially to some extent in the Canadian aircraft industry.

Research work carried out by Hildebrand[8] has shown that ZK51A alloy (Mg + 5% Zn + 0.7% Zr) possesses a good combination of yield strength and elongation. In this respect the alloy is believed to have utility where this combination of properties can be used.

Figure 5 shows the properties of separately cast test bars as a function of the zinc content. These data in the T5 condition (as cast and aged) show a leveling off in tensile properties at about 5% zinc.

It is claimed in some of the literature pertaining to this alloy system[2, 4] that the Mg-5 Zn-Zr composition is useful in applica-

[6] "Some Effects of Zirconium on Extrusion Properties of Magnesium-Base Alloys Containing Zinc", by J. P. Doan and G. Ansel, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 171, 1947, p. 286.

Table V – Fatigue Properties of Mg-Zn-Zr (ZK51A) Compared With Mg-Al Alloys

Alloy and Condition	Test Temperature	R. R. Moore—Rotating Beam Fatigue						Krouse Plate Bending Fatigue†					
		Stress in Plain Bar at Cycles		Stress in Notched Bar, SCF*-2 at Cycles		Stress in Notched Bar, SCF*-5 at Cycles		As-Cast Surface, Stress (1000 Psi.) at Cycles			Machined Surface, Stress (1000 Psi.) at Cycles		
		10^6	10^8	10^6	10^8	10^6	10^8	10^5	10^6	10^7	10^5	10^6	10^7
ZK51A-T5	70° F.	11	9	11	9	10	6	15	7	6	17	10	9
AZ63A-T4	70	18	14	12	8	8	7	12	10	8	15	13	12
AZ92A-T6	70	18	15	11	9	6	5	14	10	9	20	16	13
ZK51A-T5	300	11	8	7	5						8	7	7
AZ63A-T4	275			8	5								
AZ63A-T6	300										12	9	6
AZ92A-T6	275	13.5	10	8.7	6								

*Stress concentration factor determined from geometry of the notch and nature of the applied load.

†Tests made for completely reversed stressing with a mean stress of zero.

tions such as aircraft landing wheels. To be sure, such an application requires an alloy possessing good toughness. However, fatigue is also an important criterion here. Hildebrand reported, as shown in Table V, a comparison of the fatigue characteristics of ZK51A alloy with the conventional Mg-Al base alloys. No distinct advantage can be seen in these data for the Zn-Zr alloy.

In Table VI the creep strength of ZK51A alloy is compared with AZ63A and AZ92A alloys. It can be seen that these three alloys are all quite similar in this property, and, by comparison with the rare earth metal or thorium alloys, are not particularly well suited for applications requiring good creep resistance.

As with the other zirconium alloys discussed above, the castability of the Mg-Zn-Zr alloys is not all that might be desired. The ZK51A and related alloys are different, however, from the Mg-RE and Mg-Th alloys. The Mg-Zn-Zr alloys, because of the high zinc content, are quite hot short. They exhibit a strong tendency to draws, surface shrinks and cracks, and many risers are needed to obtain castings free from microshrinkage. Complex castings have been made in this alloy system in this country, Canada and England, but large-scale commercial use of the alloy may be limited by high cost and poor castability. In view of its mechanical properties, it would seem as though this alloy is limited in its utility to applications where a combination of high room-temperature elongation and yield strength is required.

ALLOYING WITH ZIRCONIUM

The alloying of zirconium to magnesium is not accomplished as simply as is the alloying of aluminum or zinc, which melt at the temperatures of molten magnesium and also possess unlimited solubility in the liquid state with magnesium. On the other hand, zirconium metal is a solid at normal molten magnesium temperatures, and the solubility of zirconium in liquid magnesium is very definitely limited to less than 1%. These factors, coupled with the fact that the supply of metallic zirconium is limited, have made it necessary to resort to special techniques for alloying zirconium to magnesium alloys.

Sauerwald[9] has shown an equilibrium diagram for the magnesium-zirconium binary system. This diagram indicates that about 0.6% zirconium is the maximum solubility that exists at temperatures in the neighborhood of 1400° F. This maximum solubility varies a little by the addition of a second or third alloying element. The approximate maximum liquid solubility of zirconium in magnesium alloys containing thorium, zinc, or rare earth elements is as follows:

Elements Added	Solubility of Zirconium
No addition	0.60%
5% Zn	0.85
3% RE	0.60
3% RE + 3% Zn	0.70
3% Th	0.90

Melting Techniques With Zr as Alloy

Several methods for alloying zirconium to magnesium have been proposed. While many of the methods are undoubtedly satisfactory from the technical standpoint, economics would rule some of them out of the picture. Ball[1] and Millward[2] prefer the reduction of complex salts containing zirconium fluoride. The zirconium chloride reduction technique has been used in this country and Canada with successful results for many years. These reductions are carried out by stirring the salt mixture into molten magnesium. The salt is reduced to zirconium which dissolves in the melt and some of the magnesium is converted to the fluoride or chloride in the process.

According to E. F. Emley (*Journal*, Institute

[7]"Magnesium Foundry Practice in Canada", by M. W. Martinson and J. W. Meier, *Transactions*, American Foundrymen's Society, Vol. 58, 1950, p. 742.

[8]"Mechanical Properties of Sand-Cast Magnesium-Zinc-Zirconium Alloys", by J. F. Hildebrand and F. P. Strieter, *Transactions*, American Foundrymen's Society, Vol. 60, 1952, p. 595.

[9]"Das Zustandsdiagramm Magnesium-Zirkonium", by F. Sauerwald, *Zeitschrift für Anorganische Chemie*, Vol. 255, 1947, p. 212.

Table VI – Creep Limit of ZK51A as Compared With Mg-Al Alloys

Alloy and Condition	Test Temperature	Creep Limit in 100 Hr.		
		0.1% Creep Extension	0.2% Total Extension	0.5% Total Extension
ZK51A-T5	200° F.	10,000 psi.	8,100 psi.	14,000 psi.
	300	5,000	5,000	11,400
	400	1,600	2,200	4,260
AZ63A-T6	300	3,500	4,000	8,500
	400	1,300	1,800	2,800
AZ92A-T6	200	8,500	7,800	13,500
	300	3,200	3,900	7,000

Merits of Three Alloys

of Metals, Vol. 75, 1949, p. 481) the chloride inclusions from the reduction of $ZrCl_4$ remain in the melt and cause corrosion; therefore, he prefers a master salt containing zirconium fluoride. The resulting magnesium fluoride is removed from the melt by means of a high-density refining flux.

Saunders[10] approached the alloying problem somewhat differently. He states that experience has shown that flux inclusions need not influence the choice of zirconium alloying agent because the use of careful but straightforward handling techniques eliminates the chloride contamination problem. He shows that there are several technically acceptable materials for alloying zirconium to magnesium. Zirconium sponge made by the Kroll process[11] produces consistent results but requires a large amount of work to make the alloy. The double chlorides of potassium and zirconium are useful and satisfactory, although sometimes the presence of the residual $MgCl_2 + KCl$ in the sludge is undesirable. Fluorides of zirconium with other salts gave considerably lower alloying efficiency than either the sponge or the chloride.

The use of a Mg-Zr hardener, according to Saunders, results in an alloying agent which is dependable, efficient, and convenient to use in production operations. The hardener is made by reacting large quantities of zirconium tetrachloride with magnesium. After a large portion of the magnesium has been converted to $MgCl_2$, the remaining Mg is associated in the bottom of the pot with the metallic zirconium in the form of a mush. This mush, when cast into convenient form, is a satisfactory hardener for use in alloying zirconium to other magnesium alloy melts. A hardener of this type is used commercially at the present time in the manufacture of Mg-Zr castings. Figure 6 illustrates the amount of zirconium obtained in magnesium alloy melts as a result of using various alloying agents. It shows the relative inefficiency of the fluoride agent tried as compared with chlorides or metallic forms.

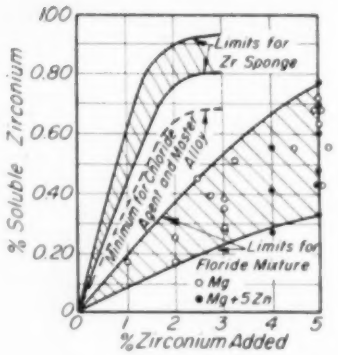
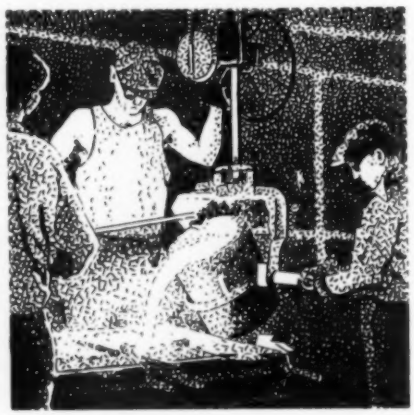


Fig. 6 – The Alloying of Zr to Mg + 5% Zn Using Chloride Agent (Fused $ZrCl_4 + KCl$ or $ZrCl_4 + KCl + NaCl$), MgZr hardener (K30A) and Fluoride Mixture (K_2ZrF_6 + Alkali Metal Chloride) at 1400° F.

Conclusions – Zirconium-containing cast magnesium alloys are becoming increasingly more important in the magnesium industry. Three different alloy systems (Mg-RE, Mg-Th, and Mg-Zn) require the use of zirconium to obtain castability and mechanical properties satisfactory for commercial use. The primary function of the zirconium is to produce a fine as-cast grain size. Much of the property improvement which results from the zirconium addition occurs as a result of the grain refinement.

Mg-RE-Zr alloys are useful primarily because of their creep resistance at temperatures of 400 to 600° F. Mg-Th-Zr alloys are still in the experimental stage, but their utility will be based on the improved creep resistance which they possess over the rare earth metal alloys at 500 to 700° F. Mg-Zn-Zr alloys possess a good combination of elongation and yield strength at room temperature. This combination should make these alloys useful in limited applications when their castability is improved.

Zirconium can be alloyed to magnesium from several different sources. Since metallic zirconium is not plentiful and also since its alloying rate is slow, salt reduction processes have been used for production operations. The use of a Mg-Zr hardener made by the magnesium reduction of $ZrCl_4$ is proving to be convenient and economical for production foundries.



[10]"Alloying Zirconium to Magnesium", by W. P. Saunders and F. P. Strieter, *Transactions*, American Foundrymen's Society, Vol. 60, 1952, p. 581.

[11]"Recent Progress in the Metallurgy of Malleable Zirconium", by W. J. Kroll and others, *Transactions*, Electrochemical Society, Vol. 92, 1947, p. 99.

New Metallurgical Research Center in France

FRANCE'S impressive new Research Institute for Ferrous Metallurgy, completed last April after six years of planning and building, occupies a group of buildings in a pleasantly wooded 17-acre parcel of land in Saint-Germain-en-Laye, northwest of Paris. This Institute has no direct counterpart in the U. S. Its laboratories and facilities might be roughly compared to those of Battelle Memorial Institute or Mellon Institute, but instead of being privately endowed, it is sponsored by the French Iron and Steel Federation (Chambre Syndicale de la Siderurgie) and is under the control of the Ministry of Commerce and Industry of the French Government. It is financed by a levy on the sale of steel and iron.

The principal purpose of this "Institut de Recherches de la Siderurgie" (IRSID in alphabet language) is to conduct technical and scientific research on all aspects of ferrous metallurgy which appear to lend themselves better to collective than to individual research. In addition to the main laboratory facilities near Paris, a pilot plant is operated for the study of minerals at Saulnes near the Belgian border, and several research projects are being sponsored at university laboratories and at some of the important steel plants. The Institute also collaborates with other organizations, both in France and in other countries, in joint researches of general interest. Examples of these are studies on the Lorraine coking coals, on ingot molds, heat resistant steels, railroad rails and tires, enameling sheet, weldability of steel and corrosion. Investigations are being conducted on an international scale on flame radiation and on the low-shaft furnace.

Supplementing these principal research activities and projects, IRSID was requested by the French Iron and Steel Federation in 1950 to establish at Metz a center for advanced studies in ferrous metallurgy, designed to round out the education of graduate engineers who have already spent two or three years in industry. Finally, it maintains direct connections with the Center for Iron and Steel Docu-

mentation, and contributes to its financing.

The Administrative Council, a group composed of 11 members who are appointed for two years by the French Iron and Steel Federation, defines the general policies of IRSID and controls its financial management. Meetings are held about every two months, and are attended by a representative of the Ministry of Commerce and Industry as well as by a direct representative of the Federation.

The Scientific and Technical Committee decides upon research programs within the general framework of directives provided by the Administrative Council. The 13 members include company executives, production heads, directors of industrial laboratories, and a representative of the National Center for Scientific Research. They meet four times a year.

The Scientific Commission is in charge of deciding upon the actual research programs at the Institute and serves as liaison with universities and plant laboratories. This commission, headed by P. Chevenard, consists of six university professors, experienced in specific fields related to metallurgy (for example, mineralogy, physics, X-rays, chemistry, radioactivity) and six metallurgical scientists. It meets regularly two or three times a year.

As stated above, finances are provided by a direct levy on industry. In France prices of common steels and cast iron are fixed by government authority, and contributions to the Institute are obligatory. Present levies are fixed at 105 francs per ton of steel and 68 francs per ton of pig iron (about 0.3% of the value of the product). Since the prices of alloy and special steels are no longer fixed by the Administration, contributions on this basis are entirely voluntary; at present they run about 168 francs per ton of steel produced.

ORGANIZATION OF THE INSTITUTE AND PERSONNEL

President of the Institute is H. Malcor, who is a member of both the Administrative Council and the Scientific and Technical Committee. The laboratories at Saint-Germain-en-Laye are headed by G. Delbart, administrator and scientific director of the Institute, and M. Allard, general director. Albert Portevin serves as scientific counsellor to IRSID. There are 350 members on the permanent staff.

The Institute's activities are organized in various divisions and departments. Some of these research projects are housed at the Center's headquarters, others at various outside organizations. The latter include the mineral division, coke and pig iron division, steelmaking division, and rolling mill division.

Headquarters for the mineral division are at a small mineralogy laboratory in Paris; the work consists largely in making a descriptive inventory of the mineral resources of France and studying processes for ore beneficiation and reduction in a pilot plant at Saulnes. The coke and pig iron division is installed close to several large steel manufacturing plants at Longwy. Its purpose is to study the blast furnace, particularly with a view to utilizing lower-grade coke and ores.

The steelmaking division has its headquarters at the Saint-Germain laboratories, but most of the personnel work in the research departments of the large manufacturers. While their province is the study of all aspects of steelmaking, emphasis is placed primarily on Thomas (basic bessemer) steel; specific projects include prerefining of pig iron, use of oxygen for blowing, and effervescence in the ingot mold.

While the rolling mill division has not yet been completely organized, certain problems are being studied in collaboration with the School of Mines at Saint-Etienne – notably projects on hot workability, extension during rolling, and calculation of stresses in rolling mill stands.

The main laboratories at Saint-Germain are organized in three departments and one division – namely, the metallographic department, physics department, analytical chemistry department, and the high-temperature physical chemistry division. The metallographic department is much more extensive in scope than its name would indicate. In fact, its jurisdiction includes general studies of properties of steels and irons in the solid state, including mechanical tests at both high and low temperatures, and research on the behavior of ferrous products in service. Some of the studies under way at the present time have to do with heterogeneity of steel, internal friction, fatigue tests, heat resistance of steels, service failures of railroad rails and tires, low-temperature behavior of welded steel structures, and preparation of an atlas of S-curves for French structural steels.

The physics department is currently limited to researches utilizing X-rays. Two present projects have to do with plastic deformation of metals and structural transformations in steel. The chemical analysis department makes

special analyses requested by the other divisions of the laboratories, conducts corrosion tests and handles general chemical problems.

The high-temperature physical chemistry division has instituted some fundamental investigations of physical chemistry of steelmaking, including viscosity, surface tension of liquid metals, and thermodynamics of sulphur and silicon with particular reference to desulphurization in the blast furnace.

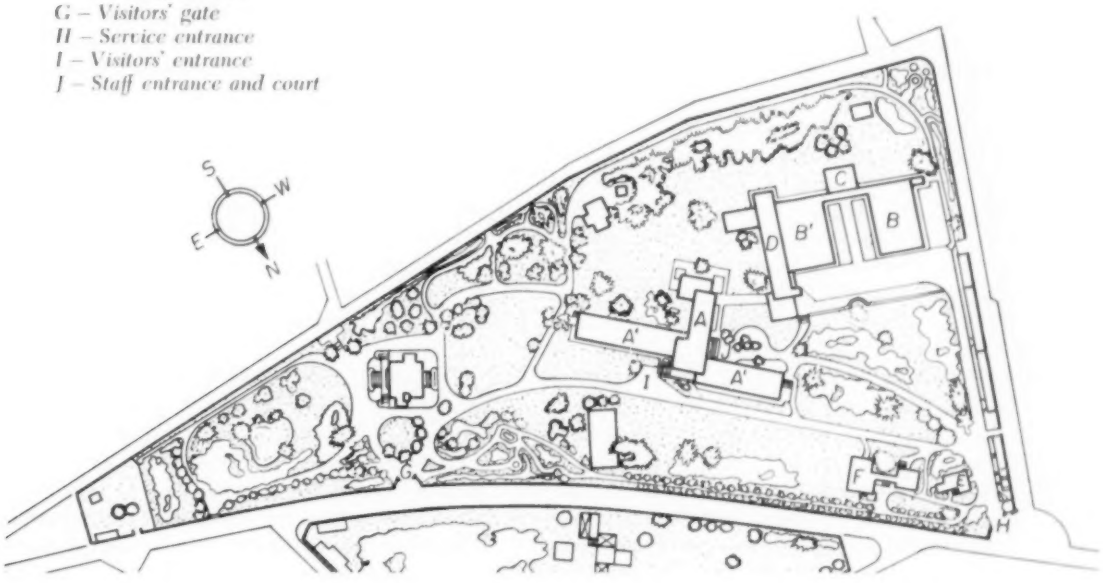
In addition there are a general services division, which has jurisdiction over equipment and maintenance; statistical division, which makes statistical analyses of test results; documentation division, which manages a library of 1100 volumes and 119 periodicals; and administrative division.

A small portion of the IRSID payroll goes to a number of young engineers who are pursuing special studies in other French or foreign universities or laboratories for a year or so with the idea that they will return to the laboratories near Paris and apply whatever new techniques have been learned. In the United States IRSID now has such representatives at Massachusetts Institute of Technology, Institute for the Study of Metals at the University of Chicago, Carnegie Institute of Technology, and Lehigh University.

IRSID attempts to maintain close relationship with metallurgical industries and also to work in collaboration with other fields of science wherever possible. To realize this ambition its staff members participate in a number of technical committees, such as those on beneficiation of minerals, heterogeneity in ingots, and boron steel, in addition to the two international committees on flame radiation and the low-shaft blast furnace mentioned at the beginning of this article.

Fig. 1 – General Plan of Research Center at Saint-Germain-en-Laye, Indicating Principal Buildings

A – Administration offices
A' – Physical and chemical laboratories
B – Melting and forge shops
B' – Machine shop
C – Electric substation
D – Mechanical testing laboratory and offices
E – Grounds supervisor
F – General services
G – Visitors' gate
H – Service entrance
I – Visitors' entrance
J – Staff entrance and court



PLANT AND EQUIPMENT

The Center represents the latest developments in laboratory design, borrowing the best features of other famous European metallurgical laboratories and incorporating some new features of its own.

Architect R. A. Coulon has laid out the main building (A in Fig. 1) in the form of an asymmetric T, 360 ft. wide and 125 ft. deep along the central wing, which will allow expansion of any portion of the structure without destroying the present balance of design. Administration occupies the central wing of the building, the physical and metallographic laboratories are in the left wing, and the chemical laboratories are in the right.

These three wings conjoin in a central Hall

French Research Center

of Honor featuring a clear glass façade extending from the floor to its overhanging terraced roof. Springing from the center of the hall is the sweeping all-steel spiral staircase of this month's front cover. This unusual construction was built after exhaustive calculations and tests on a one-fifth scale model had been made. The 30-ft.-long spiral box beam of trapezoidal cross section is built up from 0.560 in. thick openhearth mild steel plate ground to 180 grit finish, Bonderized and finished with a colorless alkyd resin varnish. The inclined faces are welded from three plates, and the top and bottom faces welded from two plates. The steps are rubber treaded steel, and the trellis balustrade is constructed of drawn steel rod.

Both the physical and chemical wings of the building are three stories high with interleaved mezzanine floors that conceal all service lines. Laboratories are separated by either glass or opaque partitions. The latter feature C-shaped anchor moldings to which apparatus may be clamped for support.

Along the back of the first floor of the physics wing are storerooms, cloakrooms, darkrooms, and an X-ray diffraction laboratory. Along the front are the radiographic laboratories and rooms for pyrometry, dilatometry and colorimetry. The first floor houses laboratories for X-ray and electron diffraction work, electrical and magnetic testing, and mechanical testing of microspecimens. On the top floor is the metallographic department which contains equipment for microscopy, macroscopy, heat treatment of small specimens, salt baths, and isothermal dilatometers for establishing TTT-curves.

Laboratories for spectrographic analysis and analysis of gases in metals are on the first floor of the chemistry wing. On the second floor are the corrosion laboratories, and the physicochemical laboratories with equipment for measuring viscosities, surface tensions, and densities of slags as well as calorimeter bombs. Laboratories for general chemical analysis are on the top floor.

The Jean Rist Laboratory (named after IRSID's first director) is the other principal building in the group (B, C and D in Fig. 1). Connected by tunnels to the main building, it is laid out roughly in the shape of a U. The two main wings (B, B′) are steel frame shops 39 ft. wide, 110 ft. long, and 32 ft. high. The right-hand wing (B) houses the melting and forge shops, the left wing (B′) is the machine shop. The central section (C) is an electric substation. Abutting the machine shop is a reinforced concrete building (D) housing the mechanical testing laboratory on its first floor and offices on the second. Each of the shop buildings is equipped with two 3-ton cranes. Present equipment in the melting shop includes a 10-kw., 200,000-cycle Philips electronic generator for 5-kg. melts of steel, and two high-frequency furnaces, one for handling 300-kg. melts under atmosphere, the other for melting and casting 50-kg. melts under a vacuum of 0.1 mm. Hg.

The forge shop is equipped with an air hammer and recirculating furnace which can heat work to a forging temperature of 2450° F.

The machine shop, with some 44 units including lathes, milling machines, drill presses, saws, grinders, and heat treat furnaces, produces both test specimens and special equipment for the laboratory.

The mechanical testing laboratory is equipped with five tensile testing machines, nine fatigue testing machines, three hardness testers, two torsion testing machines, a universal sheet tester, three Charpy impact testing machines (one an Amsler universal machine that can also test Izod bars), a magnetic sorter and metalloscope.

The creep testing laboratory has 22 creep machines on the first floor and 14 stress-rupture machines installed in the basement. Temperature of the stress-rupture machines is recorded on one central potentiometer. These two rooms are Carrier air-conditioned within ¼°. The zone from a foot and a half to four and a half feet above the floor is free of air currents. To completely avoid drafts on the creep equipment, however, a protective screen is thrown around each machine.

In addition to the two main buildings a number of service buildings are scattered over the grounds, of which the more important are the general service buildings in the northern corner of the property (E and F in Fig. 1). This group includes the building superintendent's quarters, the purchasing department, instrument maintenance department, and the infirmary.

The entire Center has been designed as an architecturally handsome group of buildings as well as headquarters for complete and modern research facilities with ample space for expansion. A good start has been made on a number of important projects, and the metallurgical fraternity can expect to hear a great deal from IRSID and its staff.

Continuous Casting of Steel Billets

Critical Points

by the Editor

IT IS ALWAYS worth while to stop over for a visit at Babcock & Wilcox Tube Co. at Beaver Falls, Pa., because management and staff entertain a healthy suspicion that conventional tube mills are somewhat less than perfectly constructed for ideal operation, and so they are willing to spend considerable money and effort investigating radical ideas for improvement. For example, a full-scale try is now being made of the Ugine-Séjournet process, which uses molten glass as a lubricant in the extrusion of hot steel billets into seamless tubes. The steel must be hot enough to be plastic, and this is too hot for organic lubricants, so a glass cloth which softens at working temperature is wrapped around the billet before putting it into the extrusion press. A sock of glass cloth also covers the piercing plug, and the brittle glass film outside and inside the finished tube is removed by a caustic pickle.

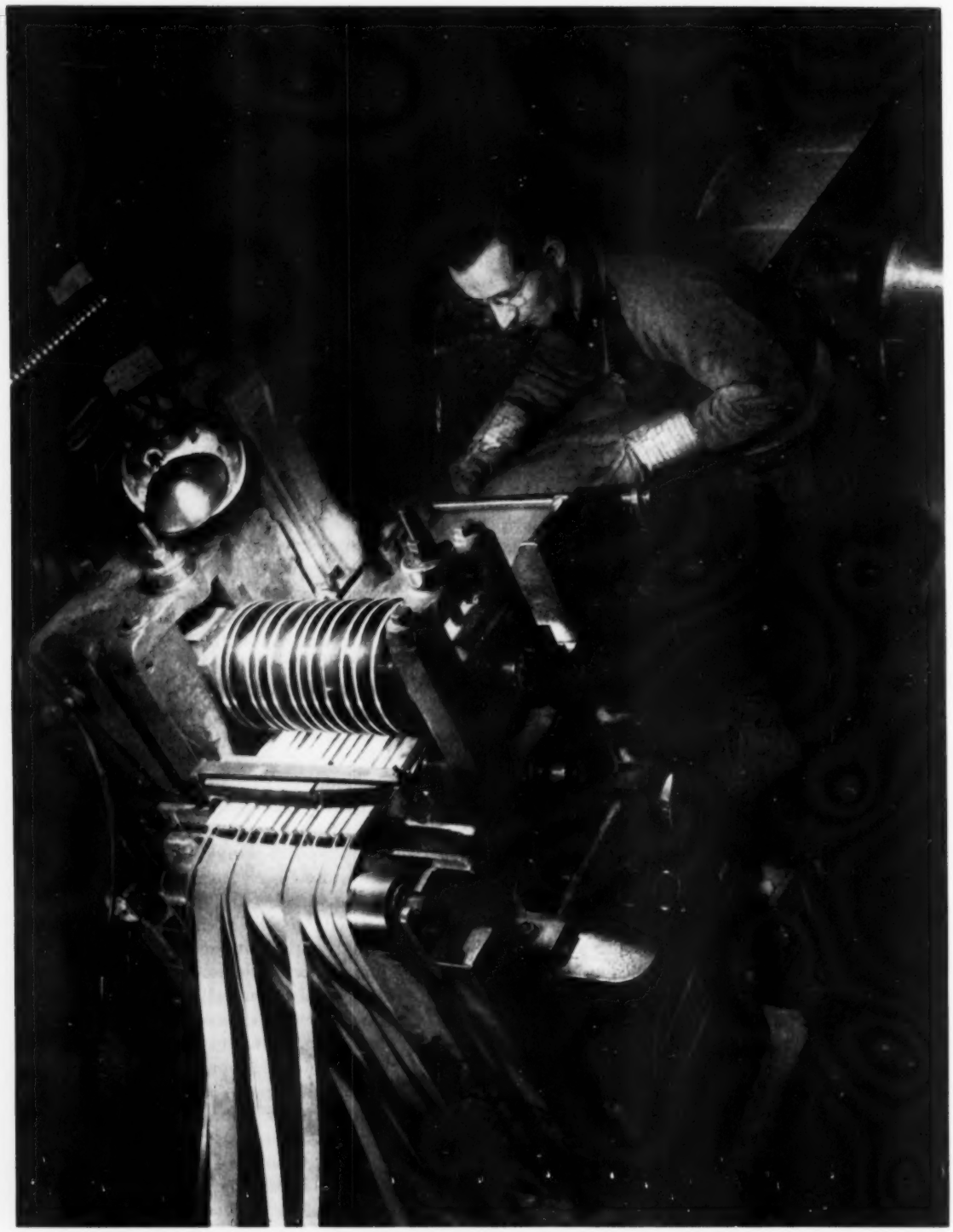
Also the Perrin process for fast refining of steel is again under serious study in this country. This was first described in *Metal Progress* in February 1933 in a letter from France by Albert Portevin. A pot of very hot, fluid, high-alumina slag receives a stream of molten metal, and the refining reactions between slag and shotted metal particles are exceedingly rapid. These reactions occur at metal-slag interface, and small metal globules are practically all surface.

Equally important news is of the continuous casting of steel billets, now after seven years of intensive work jointly financed by Babcock & Wilcox Tube Co. and Republic Steel Corp. at a stage where allowable casting speeds make the process economical, not only for high-cost stainless and engineering alloy steels but also for the low-carbon grades. As in the continuous casting of aluminum or brass, the art is to pour metal into a water-cooled ring, open top and bottom, at exactly the rate it solidifies, continuously withdrawing the ingot downward so the liquid level remains constant. Alloy aluminum ingots can be cast in a ring whose height is measured in inches; steel requires a mold ten times as high.

In the pilot plant at Beaver Falls, refined steel is poured from a 7-ton electric furnace, whose tilting mechanism is especially designed for smooth, slow operation, into a tun-dish. This tun-dish is essentially a trough with three skimmers to hold back any small amount of floating slag; it is mounted on a carriage like a crane trolley and provided with sidewise, up-and-down and tilting motions. Thus, it is able to fulfill its twin bill of being a slag skimmer and a steering device to put molten steel at the center of the open mold at exactly the right rate. Experience has proven that lip pouring gives far more uniform and controllable rates than bottom-pour nozzles.

At the start of the cast a long dummy occupies the position of a completed billet; its square top represents the ingot stool. A quantity of argon clears most of the air out of the shallow mold and serves as a blanket to protect the molten metal from oxidation. When casting is under way a little castor oil is introduced; it cracks into a voluminous product with high affinity for oxygen. Liquid level is maintained by balancing the rate of pour against the rate of withdrawal; this is done automatically by electronic devices receiving their signal from an X-ray beam transmitted through the mold assembly at the correct level for the liquid steel.

Descent of the billet must obviously be related to the rate at which heat can be extracted from the steel within the long brass mold. To the Editor it would appear that another prime requirement would be to extract heat from hot steel at a wholly unprecedented rate. In a long mold such as used here there is a conflict of factors. At the very top the liquid steel is in close contact with the brass mold, thermal conductivity is high, and a thin, solid skin forms almost instantly. This skin or shell grows in thickness and is further cooled on its slow downward travel and tends to contract away from the mold, whereupon thermal conductivity from hot ingot to cold mold would be sharply reduced. This allows the thin skin to be reheated by the liquid center, softening it enough so the shell again expands to re-establish contact with the mold. This balance of compensating factors is maintained until there is no longer sufficient heat in the liquid center to soften the supporting envelope; at this time the solidified shell must be thick and strong enough to contain the mushy center. It is important that the mold itself should be no longer than is required to freeze such a skin. Just below the mold this billet then descends between sets of closely



Slitting the Thin "Hipersil" Strip for Miniature Transformer Cores, Half the Size of Your Little Finger, for Walkie-Talkie Radios, and for Communications Equipment in Tanks, Aircraft, Submarines, and Other Places Where Space Is at a Premium. This improved silicon steel requires less copper in the transformer coils, eliminates half the nickel in the unit, and avoids much slow hand work in the construction. (Westinghouse photo)

nested rollers, gently supporting it from four sides, and is simultaneously drenched with water sprays. Just below these roller-guides is a set of pinch rolls which carry the weight and regulate the speed of descent. The descending billet is flame-cut to stated length, and the severed end is caught in a tall basket which tilts it horizontally onto a run-out table.

At the time of the Editor's visit a 7-ton heat of steel was being cast into 7-in. square billets in about 20 min., which means that the billet moves down at the rate of about 4 ft. per min. One such casting machine could apparently handle the output of properly synchronized steel furnaces aggregating 500 tons daily.

Despite the fact that Babcock & Wilcox's electric steel furnaces have 225 tons rated capacity daily, this is not enough to keep a blooming mill busy; at present, ingots cast in the ordinary way are forged down to billet size. It is obvious, therefore, that the engineering staff would be interested in any device which would eliminate the hammer and press. H. D. Newell, chief metallurgist, said that final inspection data on about 700 tons of tubes showed that the continuous-cast billet filled every requirement for highest quality seamless tubes – indeed, it has such a superior surface that scalping costs are unusually low. No segregation can be detected by spectrographic analysis in any of the common elements in carbon and stainless steels. Casting through tun-dish into an oxygen-free mold should also insure a minimum of slag or oxide inclusions.

First success was achieved in an oval cross section, about 4 in. by 2½ in., but this was difficult to roll into rounds. Round-cornered, 7-in. square billets are now in regular production, and after reheating are rolled directly into round billets for the piercing mills. Immediate future plans include experiments on rectangular molds for producing slabs of various sizes.

The Carolinas Chapter

TO WINSTON-SALEM, to be the first "technical speaker" before the newly organized The Carolinas Chapter of the ASM. It was attended by two thirds of the members in that region, some coming from as far distant as 90 miles. Robert W. Marshall, assistant superintendent of engineering of Western Electric Co.'s numerous radar plants in North Carolina, in his coffee talk described the remarkable increase in manufacturing in the South since World War II, as much new industry being established in a single recent year, measured by capital invested in the plants, as the total prewar valuation of the manufacturing establishments in the entire South. This has resulted in a migration of about half the white population from the Carolina farms into the cities – again possible only because of mechanization of agriculture. Farm boys and girls are excellent help, having been used to doing so many things with their hands that they are readily trained in mechanical operations, but he pointed to a grave shortage in engineers and technologists, nearly all of whom have to be imported from the northern and central states, and even there the supply is seriously limited. He suggested that The Carolinas Chapter and its members could perform an invaluable service by promoting engineering, science or technology as a career to the high schoolers (in past decades practically all the bright youngsters in the South studied for the law or medicine, or entered commerce, the church or the armed forces), and by insisting on better and more engineering and scientific instruction in colleges and universities throughout the Carolinas – a course of action, the Editor was glad to add, which exactly parallels the fundamental objectives of the American Society for Metals and all its traditional activities. The recently established American Society for Metals Foundation for Education and Research will also be a powerful force in this same direction.

Opportunities for Metallurgists

SPENT SEVERAL interesting hours at "Research Day" held at Case Institute of Technology, when that Cleveland engineering college tells industry once a year about the various investigations under way in its chemical, metallurgical and physics departments, and was pleased to see a large assembly of good men from as far east as New York City and as far west as Chicago. Kenneth H. Donaldson, head of the department of metallurgical engineering, opened the meeting with a talk about our ore resources, and re-emphasized the well-known fact that in the last 50 years the United States is continually becoming more dependent on foreign supplies – a circumstance which might well be disastrous in war, whatever may be said of it as a useful balance for foreign trade in peacetime. He could have given high praise to the copper industry for its intensive engineering work prior to World War I which converted it from operations based on 6% ore to others equally

Critical Points

efficient on 1% ore, and he might perhaps have been somewhat critical of the iron industry for its tardy recognition of the fact that the bonanza deposits in the Iron Ranges are not illimitable, and belatedly turning attention to the concentration of iron from the lower-grade country rock existing there in astronomical amounts. Of course economics rule every competitive situation and one can hardly blame the metal industry, for example, for using cheap Canadian nickel as long as it can be had, rather than working out difficult problems connected with the world's largest nickel deposit – the laterite ore of Cuba – all the more interesting because it contains 1.7% chromium and 0.1% cobalt in addition to 1.0% nickel and 46% iron. Meanwhile nickel tops the list of essential alloying metals "in short supply".

Certainly the future holds enormous opportunities for the American metallurgist and metallurgical chemist in devising economical and workable methods for separating the values from such lower-grade or complex mixtures which exist close at hand, and – the Editor would venture to predict – they are no less likely to succeed than their precursors who 50 years ago tackled the copper-lead-zinc-gold-silver ores so common and so exasperatingly undesirable to our Western millmen and smeltermen. Coming back to the low-grade problem, several encouraging examples can be cited, such as the recovery of 10,000,000 lb. of molybdenum yearly (one-quarter our wartime supply) from Western porphyry copper ores containing about 5 oz. molybdenum per ton – a 0.015% "ore". Likewise, the American atomic energy program gets a considerable portion of its necessary uranium from vanadium ores in the Colorado plateau carrying about 0.25% uranium. Uranium is also being successfully recovered as a byproduct of fertilizer made from phosphate rock carrying around 0.015% uranium. Certainly the age of "trace metallurgy" is here, if we only know it and work for it.

Conservation Through Progress

LATER in the day at Case Institute, Mervin J. Kelly, educated as metallurgist at Missouri School of Mines and now president of Bell Telephone Laboratories, based a formal talk on the conservation of scarce materials, citing chapter and verse, on research in the telephone industry. His theme might have been, "If you can't get enough of the material or if it costs too much, use less of it or use something else." For example, if there is not enough tin for high-tin solder, use a low-tin solder – or, even better, no solder at all. How? Well, the Laboratories have developed a wiring "gun" which interconnects two wires under such tension that an exceedingly intimate contact is realized, into which gas and moisture cannot penetrate. No tin is needed. Such solderless contacts have been under engineering test in the laboratory and plant of the Bell System for some time, and their use in standard equipment will be rapidly extended.

Another example: Long-distance telephony was economically impossible until "repeaters" were invented to pick up a decaying signal, amplify it without distortion, and send it on its way. Repeaters made transcontinental telephony a reality, but they cost so much that their use was limited until circuits and cables were invented which could transmit many messages simultaneously over one pair of conductors and unscramble them unerringly at the other end. These two conditions were first met some 25 years ago. Since then, continuous study of repeater circuits and conductors has resulted in progressively larger savings of materials. For example, the art of 25 years ago permitted the transmission of twelve conversations on a copper conducting pair in a lead-sheathed cable. The present state of the art permits the transmission of 1800 conversations in a conductor which the Laboratories have called a "coaxial pipe". This is a thin-walled tube of copper, 0.4 in. in diameter with a copper wire running down its center, held in the axis by polythene washers spaced a few inches apart. To provide circuits for 1000 conversations between New York and San Francisco with the art of 25 years ago would require 81,000 tons of copper and 158,000 tons of lead. To provide the same channels the art of today requires only 1500 tons of copper and 43,000 tons of lead!

Dr. Kelly pointed out that, while vacuum tubes had revolutionized toll transmission, local telephoning – transmission for distances under 25 miles – is still done without repeaters. Also, electronics has not entered the switching or interconnection function which is done electromechanically by relays and switches. Recently the solid-state physicists and metallurgists of the Bell Telephone Laboratories have developed solid devices that perform most of the functions of the thermionic vacuum tubes.

(Continued on p. 182)

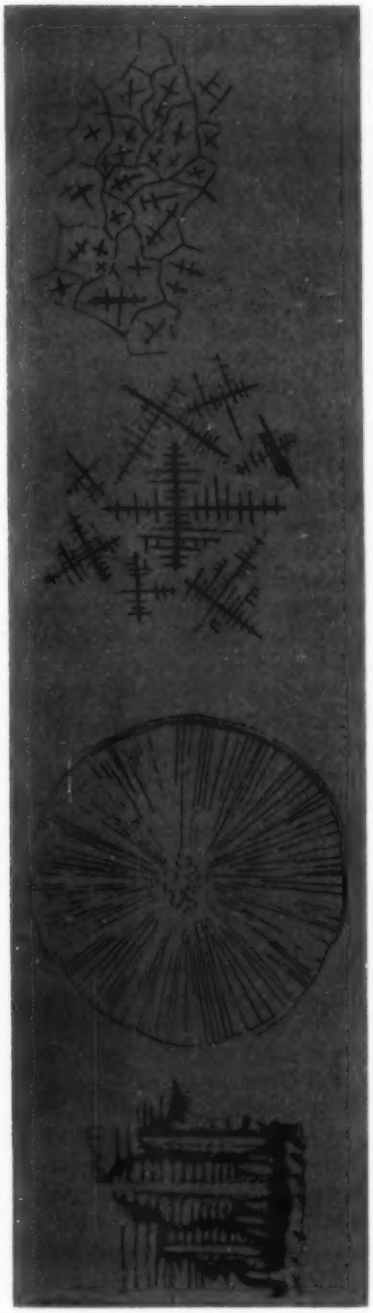


Fig. 1 – Sketches of Dendrites, Grains and Ingotism Made by Tschernoff in 1879. A new biography of this famous Russian is reviewed on p. 95

By CARL A. ZAPFFE
Consulting Metallurgist, Baltimore, Md.

Current Russian Metallurgical Texts – II

IN THE AUGUST 1951 issue of *Metal Progress* there was published under this same title a review of a number of Russian metallurgical books currently in use. Its purpose was to help metallurgists in our country attain a perspective and a general understanding of the status of Russian metallurgy as revealed by their textbooks, and also to call attention to some particularly worth-while contributions. Because of the interest and appreciation with which that review was received, the effort has been extended to cover further recent publications coming to the author's attention during 1952. All of them are official publications – that is, issued by the appropriate branch of the Governmental Scientific-Technical Publishing House in Moscow.

THE ELECTRIC FURNACE

"Electric Melting Furnaces for Ferrous Metallurgy", by N. V. Okorokov.

"As in so many other fields, the pioneers of the electrothermic industry were Russian scientists . . . .

"The electric arc, which is sometimes referred to as the 'Voltaic Arc', should in all fairness be called the 'Arc of Petrov', because it was precisely the Russian scientist V. V. Petrov who first discovered this arc in 1802, 18 years before it was discovered in Western Europe. Petrov also first conducted experiments for the utilization of the arc for illumination, electric welding, and the melting of alloys and their reduction from oxides."

Thus run the first and third paragraphs of the introduction to a 1950 book which otherwise is a prize in its field, its 563 pages and 207 figures covering most variations of arc and induction furnaces. Many tables and diagrams describe details ranging from mathematical theory for the electrical characteristics to information on furnace construction – even to cutaways showing cable design.

Neither in American nor in French literature is a parallel

likely to be found, possibly because it is designed for an educational need that is prevalent only in Central and Eastern Europe – namely, to aid senior students in electrometallurgy to perform a major project prior to graduation, such as the design of a specific furnace for a specific duty. The book draws freely from numerous sources of information, and it is on a subject having great importance for both ferrous and nonferrous operations. Germany's 1950 issue of "Elektrostahl Erzeugung", by Sommer and Pollack, is inferior to Okorokov's text; America has its information in this field scattered throughout 10 volumes of the American Institute of Mining and Metallurgical Engineers' annual *Proceedings of the Electric Furnace Steel Conference*.

GASES AND METALS

"Hydrogen and Nitrogen in Steels", by A. N. Morozov.

This 1950 book on hydrogen and nitrogen in steel is well written, though suffering from the hopeless inadequacy of 222 pages and 176 references for such a subject. The coverage is principally for wrought steel, and considers only thermal treatments – nothing on hydrogen porosity, weld cracking, pickling and plating brittleness. The discussion of nitrogen in the second half of the book skips its use as an alloying element in stainless steel and precipitation effects in ordinary steel. Nevertheless, useful information appears. The data on gas analyses for the acid openhearth are welcome, since they are scarce in our country where basic steel predominates.

The section on "flakes" is interesting in showing the extent to which this important problem has bothered the Russians. Morozov refers to a prewar "Metallurgizdat" published in 1939 on "Flakes in Steel: Answers to Questionnaire"; then to an annotated bibliography on flaking by Sorokin in 1940; to "Reports on the All-Soviet Conference on the Problem of Flakes in Steel" in 1941; and finally to a 1950 book on flakes in steel by V. Dubov. None of the extensive American work on flaking is recognized. Indeed, very few of the references on any of the subjects are other than Russian, although one can be found for what transliterates as "*Transsekshns* of Ameriken Sosaiti for Metels". Closer examination of the bibliography, however, reveals such references as "A. Shenk . . . ONTI 1936". This is obviously a wrong initial and spelling for H. Schenck, whose two classical volumes on the physical chemistry of steelmaking were published in 1932 and 1934. Accordingly, the listing discloses that Schenck's works were translated and placed in the Russian literature in 1936 by ONTI or GONTI, the Government's United Scientific-Technical Publishing House.

"Dimensional Change of Steel From Thermochemical Treatment – Carburizing and Nitriding", by S. F. Yurev.

As a second text in this field, Yurev's treatment of dimensional change during carburizing and nitriding stands in interesting contrast. No other book is known to the reviewer which has this particular subject as its text. In any event, the scholarly coverage is certainly without competition for the section on nitrogen, and among the best for the section on carbon. There are 193 references and 308 pages giving a generous coverage of the world's literature, including work as recent as that of our Morris Cohen published in 1949.

Complex mathematical analyses for dimensional changes of various shapes during nitriding and carburizing are deduced from data obtained principally from differential dilatometry. Much of the experimental work is Russian, some original with the author.

PHASE TRANSFORMATIONS IN STEEL

"Phase Transformations in Iron-Carbon Alloys", by I. N. Bogachev and A. A. Popov (editors).

At the Ural Polytechnic Institute, a series of seminars was held in 1950 on the theory and practice of the heat treatment of steel. Prominent Russian metallurgists delivered the lectures; these have been combined and edited by two of the lecturers to provide a book of eight well-integrated chapters covering 174 pages.

Opening chapters on crystallization of liquid phases and on diffusion contain fundamental discussions from both physical and thermodynamic standpoints of nucleus formation and the growth of crystals. The shifting of phase limits in equilibrium diagrams caused by changes in the radius of curvature of one of the phases is given attention considerably advanced beyond anything in the English literature known to the reviewer.

Chapters III through VIII concern the formation and decomposition of austenite, and satisfactorily cover martensite formation, tempering phenomena, TTT-charts, and compari-

sons of isothermal and anisothermal transformation products. Much less photomicrography is used than in American treatments. Descriptions lean heavily upon the justly renowned work of the Russian Kurdyumov, although there are references to Sykes in *Transactions* for 1937, and Grange and Kiefer in 1941. Further careful search of the bibliography discloses a brief: "French, Zakalka Stali, GONTI, 1933" which can be none other than H. J. French's 1931 publication on the quenching of steels — as translated and published by GONTI, unquestionably without as much as saying "by your leave".

METALLURGICAL THERMODYNAMICS

"Physical Chemistry of Pyrometallurgical Processes. I. Reactions Between Gaseous and Solid Phases", by O. A. Esin and P. V. Geld.

Another first-class contribution from Russia is provided by this text, which is Vol. I of what is apparently intended to become an exhaustive treatise on thermodynamic relationships of metallic and nonmetallic phases. This first volume concerns gas-solid reactions, a second being promised for liquid-solid. There are 510 pages and eight chapters, each having a bibliography often running near 100 references, and these generous with foreign literature.

In plan, the presentation is divided into four sections; the first is on fundamentals; the remaining three each balance a chapter on thermodynamics against a chapter on molecular physics. Thus, Chapter II details the combustion of H and CO for all possible combinations of CO, CO_2, O, O_2, O_3, H, H_2, H_2O, OH. Then Chapter III treats the combustion of solid carbon from a thermodynamic standpoint, bringing in variations with H_2O, CH_4, O and O_2, while Chapter IV expands upon the topochemical details with 120 pages and 116 references. Here the atomic structures of carbon and the reacting phases are minutely described in combination with the thermodynamic treatment, and cover many conditions of combustion, including the effects of catalyzing minerals such as $MgCl_2$, NaCl, $FeCl_3$, KCl, K_2CO_3, $Al(NO_3)_3$ in the reduction of iron oxide.

The book culminates with a treatment of the reduction of iron oxide, which constitutes as good a coverage of the thermodynamics and physical chemistry of sponge-iron processes as can be found in any literature. Those metallurgists who are currently searching for an economical process of direct reduction would do well to consult this book.

Five Nonferrous Texts

"Technical Specifications for Nonferrous Metallurgical Products", by Ministry of the Metallurgical Industry, U.S.S.R.

Here the Government steps up with a book of specifications and standards for analyses and analytical methods, machining and casting tolerances, alloy applications, wire, rod, bar, sheet, strip, foil, tubing, profile shapes, electrodes, powder, fabricating, finishing, salts, acids, reagents, and even lamps for miners' hats.

"Calculations for the Metallurgy of Heavy Nonferrous Alloys", by F. M. Loskutov and A. A. Saidler.

On a flyleaf in the front of each of the U.S.S.R. "Scientific-Technical" publications for the various branches of science there appears a paragraph or two under the signature of an official reviewer. The following "annotation" by V. A. Noumov both exemplifies this procedure and fairly describes this 1948 text on processing heavy nonferrous alloys:

"In this book exemplary calculations are explained for various processes in the metallurgy of lead, zinc, copper, nickel, and tin. Many of the calculations are accompanied by detailed considerations of stepwise unit processes and heat balance.

"The book appears to be a practical guide for production engineers, scientific personnel, and design engineers working in the field of nonferrous metallurgy, and it might also serve as a text for students of higher technical schools in conjunction with courses on the metallurgy of heavy nonferrous metals leading to an engineering diploma."

In common with most Russian books, there are no halftone illustrations, and only 16 line drawings, all dealing with viscosity measurements of slags. The 384-page text carries a conventional treatment of metallurgical calculations, drawing heavily on Allison Butts' ("Ellison Betts") "Metallurgical Problems" (1943).

"The Forming of Nonferrous Metals and Alloys by Pressure", by V. G. Serdiukov and Ya. Ya. Tsiersch.

With regard to both practical and theoretical details of processing nonferrous metals and alloys, particularly copper-base and nickel-base, this 1947 text deserves a high rating on scope and treatment, as well as a mention for its above-average typography. There are 111 references, a half-dozen tip-in folders, and 381 figures in the 508 pages, many in halftone, ex-

haustively describing metalworking machinery and the processes and problems of forming sheet, plate, strip, tubing, and profiles. Attention is given to American and European practices with which the authors are familiar. This appears to be one of the better Russian texts.

"The Metallurgy of Zinc", by F. M. Loskutov.

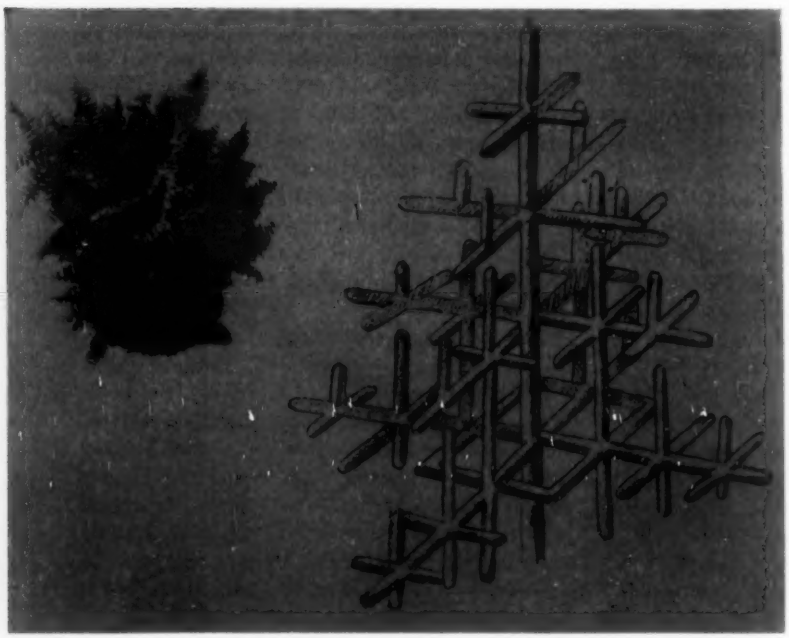
Both pyrometallurgy and hydrometallurgy, with some electroplating, are treated in Loskutov's 355-page book on zinc, but only from the standpoint of process metallurgy. Dated 1945, the material is largely from Russian sources, but the presentation often follows Hofman's "Metallurgy of Zinc" (1922), and Liddell's "Handbook of Nonferrous Metallurgy" (1926). The last chapter on "New Hydrometallurgical Processes" devotes several pages to the Tainton process (hardly "new"!), then to the Magdeburg process (high current density and strong acid electrolyte), the Makovetski process (sulphuric acid), and the chloride process.

"Hydrometallurgy", by E. N. Plaksin and D. M. Iuktanov.

This 732-page "Hydrometallurgy" is for students in higher technical schools. This work is as thoughtfully and exhaustively prepared as any comparable book in English; it contains nearly 200 illustrations. Dated 1949, it is the official U.S.S.R. summary of the ore dressing and hydrometallurgical field, prepared as a part of the Five-Year Plan for 1946-50. This field of ore dressing is given great attention in Russia – is something of a specialty with them – and this book is replete with flow sheets and informative diagrams disclosing both theoretical principles and practical approaches.

Though short on halftone cuts, a number of full-page portraits show Russian scientists prominent in the development of hydrometallurgy, the history of which is traced in detail. Some footnote references are used, and a bibliography of recommended reading segregates 25 Russian sources from 5 English, these latter including texts by Hofman (1932) on zinc, Newton and Wilson (1942) on copper, and Liddell (1945) on nonferrous metals. Pages 486 to 490 on "A Perspective of the Growth of Hydrometallurgy of Copper in the U.S.S.R." would probably interest American hydrometallurgists, as would the detailed flow sheets.

Fig. 2 – Crystallography of Dendrite Growth, and Dendritic Forms Found in Sinkheads of Castings, as Sketched by Tschernoff



HISTORICAL

"Notes on the History of the Metallurgy of the Light Metals", by A. I. Belyaev.

"Sooner or later aluminum will replace wood itself, perhaps even stone . . . everywhere aluminum for furniture and even ceilings and floors . . ."

So predicted the character Sasha during a discussion of architectural problems in Chernishevski's "Shto Delat" (What To Do?), published in 1861, but written about 1827, according to Belyaev. Although aluminum was discovered in 1825, it was not produced commercially for another 60 years, which gives Belyaev an opportunity to point to the prophetic insight shown by the Russian playwright.

Since the present review began with a claim of a Russian "first", it might appropriately close with mention of this book and another which not only feast upon this peculiar

viewpoint of the 1950 Russian, but which have real historical value as well.

In Belyaev's small volume of 142 pages, the entire history is a Russian history. He begins with exactly the same claim made by Okorokov – that V. V. Petrov was the first Russian electrochemist and electrometallurgist who, in 1802, worked with a huge voltaic cell containing 4200 copper and zinc electrodes. To shelve any doubt, the author reproduces the title page of a Petrov publication in 1803 which apparently describes the reduction of certain metals from their oxides by means of the electric arc. The story then skips to Beketova in 1865 whose doctorate thesis concerned the reduction of cryolite by magnesium to give aluminum. Twenty years later a factory was built in Germany to use this or a similar process, and a photograph of the factory is shown. Some success attended the work with magnesium, but production of aluminum proved impractical.

Also covered are the histories of other light metals, such as beryllium and lithium; the little book would make light and interesting reading for metallurgists in these industries.

"D. K. Chernov (Tschernoff)", by B. E. Volovik.

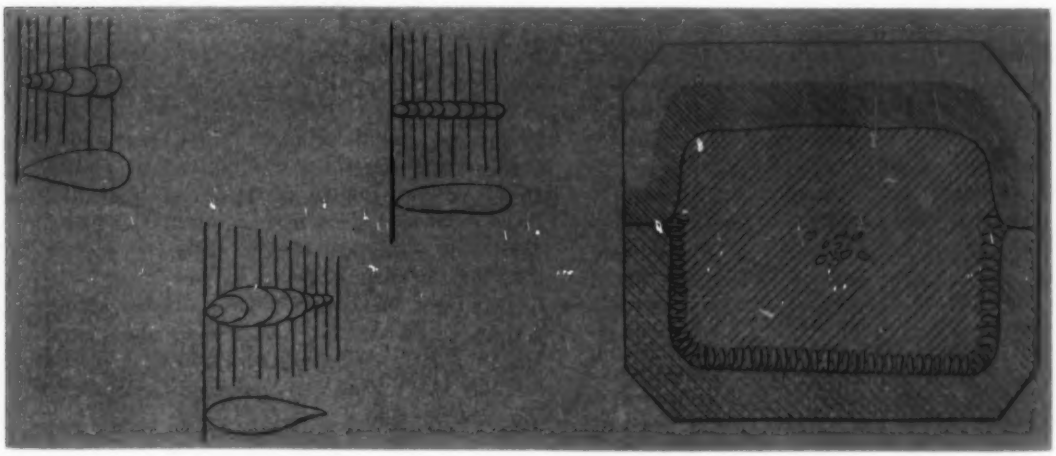
Far more important for historical metallurgy which all can enjoy is this biography of D. K. Tschernoff who died in 1921. An internationally renowned metallurgist, he remains a historical figure. Volovik's book lists 40 publications by him and another 40 about him. He began in 1868 to describe the structure of steel ingots to students, and by 1879 he had published his famous "Researches Relating to the Structure of Cast Steel Ingots" in *Communications of the Russian Technical Society*, an article reaching the western world through a French translation in 1880. His drawings and descriptions of dendrites, his explanation of dendritic growth and the development of porosity in steel castings have been published and republished down to this very day. Figure 1 shows Tschernoff's sketches of grains, dendrites, and "ingotism"; Fig. 2 details the crystallography of dendritic growth, and the dendritic forms found in pipe cavities of ingots. Figure 3 similarly details his understanding of pinhole formation.

Tschernoff, a Historical Figure

However, a study of contemporary metallurgy develops some intriguing speculation which this reviewer will here insert. For example, F. C. G. Müller began publishing his outstanding researches on pinhole porosity in Germany in 1878, and his drawings are very similar to Tschernoff's published in 1879. Then A. Martens, for whom martensite was named, published his first great contribution in 1878 in Germany with drawings of dendrites, these studies being continued up to 1886. Tschernoff's manuscript was submitted Dec. 2, 1878, some months after Martens' first paper – and also Müller's. In those days, of course, there was much scientific interchange among Germany, France, and Russia, so that one is at a loss to know who drew, for example, those sketches in Martens' and in Tschernoff's papers which are absolutely identical.

The story closes with an account of how the "English Capitalists" at one time invited Tschernoff to flee Russia and come to England to live. They made a warship available to him for this purpose and promised him better living conditions; but the "Great Patriot" refused.

Fig. 3 – Sketches of Pinhole Formations in Ingots, According to D. K. Tschernoff (1879)



Radioactive Dangers From Bomb Tests

In the 13th semi-annual report of the U. S. Atomic Energy Commission to Congress, Jan. 28, 1953, a 50-page section is devoted to "Public Safety in Continental Weapons Tests" from which the following is digested. Quotation marks represent literal transcriptions.

"Twenty nuclear devices or weapons have been exploded since early 1951 in a 640-sq.mi. tract of desert land in Nevada. Blast waves have caused minor damage as far away as Las Vegas [80 miles]. The brilliant flash of light is potentially a source of hazard as far as 30 miles. 'Fall-out' – the descent of radioactive particles [fission products] – already has caused public concern, and these statements may be made:

"*(a)* No person has been exposed to a harmful amount of radiation from fall-out.

"*(b)* Successive tests have not resulted in the accumulation of a hazardous amount of radioactivity in the soil [or food plants].

"*(c)* Fall-out radioactivity is far below the level which causes mutations or inheritable variations."

The fission products condense as oxide particles of size less than 1 micron to 10 microns in diameter. They have half-lives ranging from 37 years for Ce^{137} to 8 days for I^{131}. "The large amount of initial radioactivity in the cloud decreases rapidly. [The most penetrating and dangerous fission product, namely, gamma activity of a normal or Nagasaki-type bomb, is 820,000,000,000 curies 60 sec. after detonation; this decreases to 6,000,000,000 curies in 1 hr., to 13,000,000 in 1 week, but 80,000 curies remain after 10 years.] This residual radioactivity from the cloud is the only characteristic of an atomic explosion which has an effect at any great distance from the site. Its fall-out is recorded by a monitoring system comprising 121 fixed stations at various locations throughout the nation" and many monitoring teams and aircraft within a radius of 200 miles. In the fixed stations, airborne dust is collected on filters or gummed paper, and their activity measured by appropriate radiation counters, and compared to the normal "background" for the locality.*

The human body repairs radiation damage continually if a dosage of 0.3 roentgen per week or a total dosage of 3 roentgens in any period of 10 weeks is not exceeded. The highest radiation level so far detected outside the proving grounds was on its boundary; this "would deliver an estimated dose of 1.75 roentgens during the first 10 weeks and 2.25 roentgens during a lifetime. The highest gamma radiation in towns in the 200 to 500-mile zone was between 0.001 and 0.002 roentgen per hr. [equal to one or two wrist watches]. If an individual remained over the material for an entire lifetime, he would receive from it the maximum permissible dose for one day. Although some radioactivity from fall-out has been detected in all the fixed monitoring stations, levels generally have decreased with distance from the test site."

Another possible source of danger may be radioactive materials inhaled or taken into the body in food or water – especially those which emit alpha and beta particles of such low energy that they do not penetrate the skin. The highest concentration of radioactive particles of size most likely to be retained in the lungs (within the 200-mile zone) would give a total dosage in the first 24 hr. "approximately equal to the dose normally received by the lungs in 20 days from normal background radioactivity in the air" [and 1/500 part the safe limit for 24 hr. as determined by study of persons who have long carried considerable radium in their skeletons].

There is a possibility that fall-outs from successive detonations may reinforce each other and build up to a level where food plants would absorb dangerous quantities. "Bone-seeking radioisotopes are of greatest concern; chief among these is strontium^{90} with 25-year half-life." Composite soil samples from Nevada and surrounding states show that shortly after the third series of tests (spring of 1952), the activity due to strontium was equivalent to 27,000 disintegrations per minute per square foot. (Average natural radioactivity in the top 12 in. of the earth's crust is estimated at 1,500,000 disintegrations.) "Experimental growth of plants in soil containing thousands of times the residual fission product activity due to fall-out of strontium shows that there is no hazard from such residual activity." Strontium in plants eaten by cattle is speedily absorbed by their bones. Similarly there is no danger from fish grown in dosed waters; radioactivity of fish in the excessively contaminated lagoon at Eniwetok dropped within 60 days to a fraction of 1% what they contained immediately after the detonation.

*"Background" is radioactivity originating from heavy elements in the earth's crust and from cosmic rays. It varies widely, place to place; human beings continuously receive from 0.08 to 0.8 roentgen of radiation per year from this source. Compare this with 0.2 to 1.0 roentgen from a single X-ray examination, or 5 roentgens per year from a wrist watch with luminous dial.

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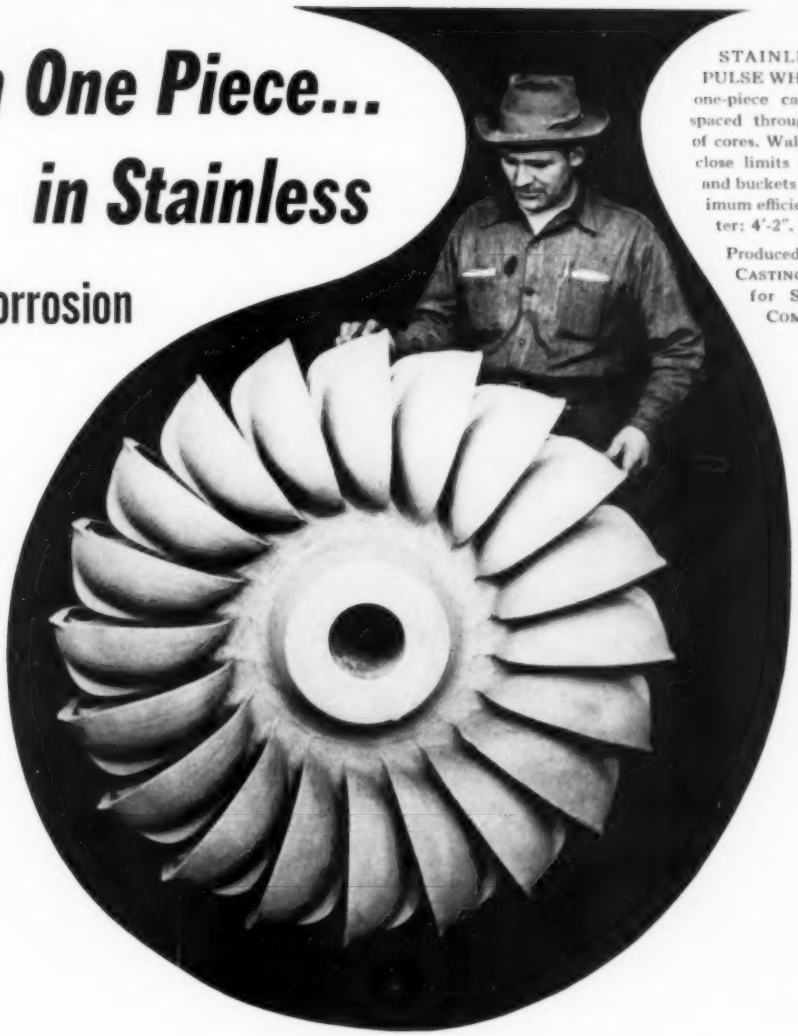

STAINLESS STEEL IMPULSE WHEEL. Buckets in this one-piece casting are accurately spaced through proper alignment of cores. Wall sections are held to close limits to maintain balance, and buckets are polished for maximum efficiency of wheel. Diameter: 4'-2". Weight: 2200#.

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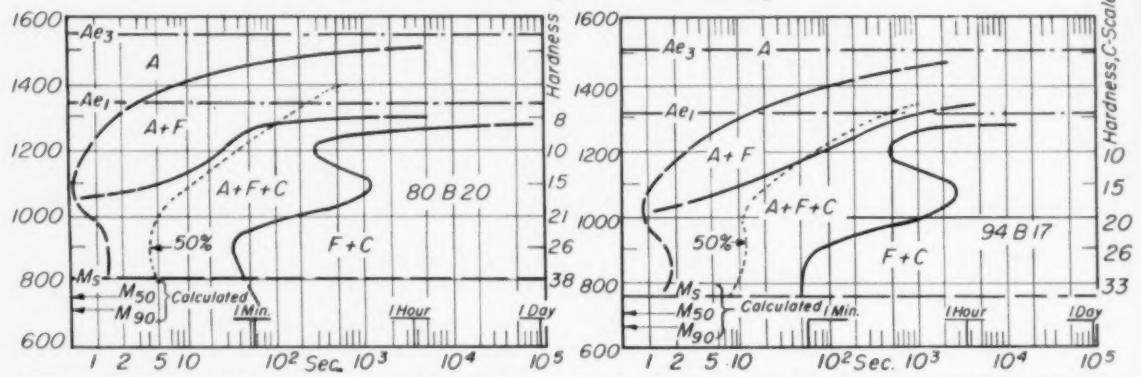
Transformation and Hardenability of Boron Steels

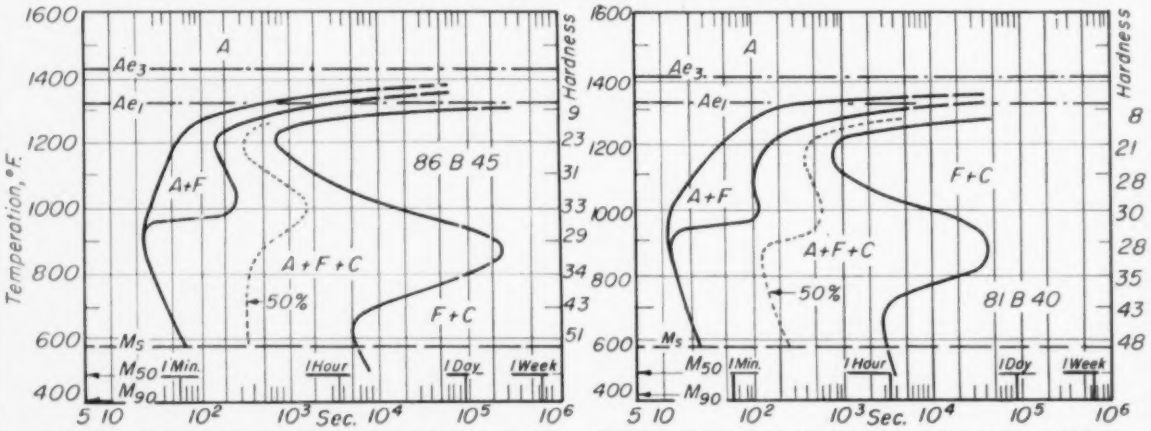
Research Laboratory, U. S. Steel Corp.



0.18 C, 0.57 Mn, 0.21 Si, 0.31 Ni, 0.31 Cr, 0.15 Mo, 0.0009 B

0.19 C, 0.77 Mn, 0.24 Si, 0.42 Ni, 0.040 Cr, 0.012 Mo, 0.0018 B

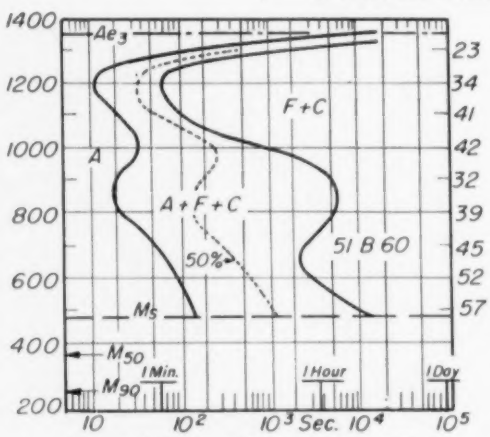
Two Boron-Treated Steels for Carburizing



0.45 C, 0.89 Mn, 0.31 Si, 0.59 Ni, 0.66 Cr, 0.12 Mo, 0.0015 B

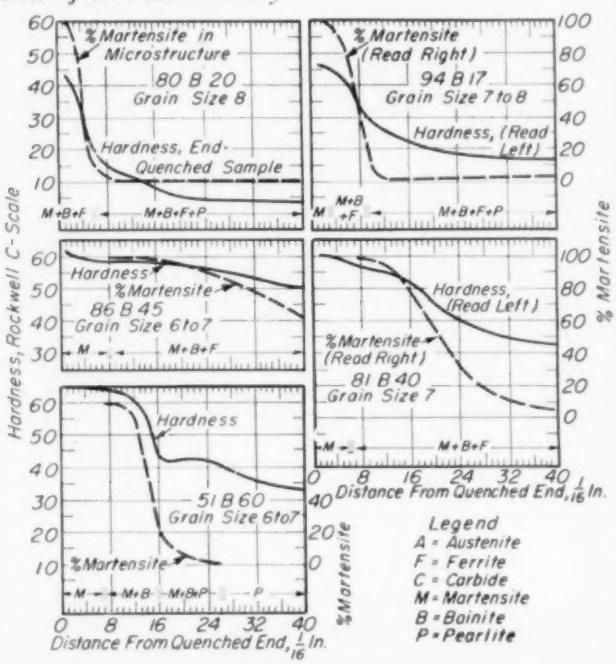
0.43 C, 1.02 Mn, 0.26 Si, 0.31 Ni, 0.48 Cr, 0.13 Mo, 0.0009 B

Two Boron-Treated Steels of Good Hardenability



0.64 C, 0.88 Mn, 0.28 Si, 0.02 Ni, 0.83 Cr, 0.03 Mo, 0.0006 B

Boron-Treated Steel for Springs



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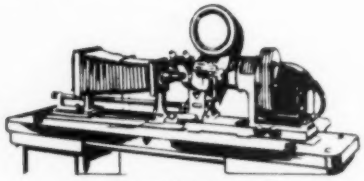
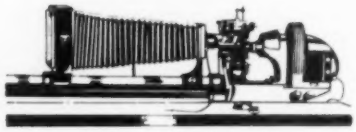


Baiphot Metallograph



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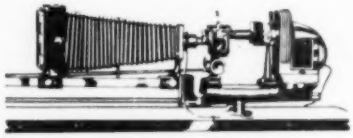

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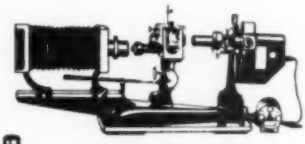

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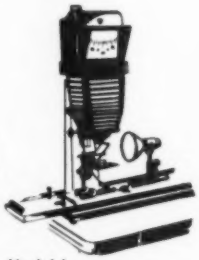

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By ROBERT N. IMHOFF, 2nd Lt., U.S.A.F., Project Engineer, and
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either 4130 or 8630 at strength levels above 150,000 psi., but is somewhat more brittle at strength levels between 125,000 and 150,000. For parts where Charpy impacts of 10 to 20 ft-lb. are adequate, 80B30 can be used down to —100° F. except in the normalized condition. The heat we tested was susceptible to temper brittleness.

As to 86B45, it was equal to 4340 in impact

Some Metallurgical Characteristics of Medium-Carbon Boron-Treated Steels

A CONSIDERABLE mass of information is available on boron-treated alloy steels in low carbon ranges and on their use in automotive and other mechanical parts – either carburized or heat treated – but very little information is available on the susceptibility to temper brittleness, low-temperature impact, fatigue and other properties of the boron-treated low-alloy steels in the middle carbon (0.30 to 0.45%) range which is of great interest to the aircraft industry. Consequently, the Materials Laboratory, Directorate of Research, Wright Air Development Center, U. S. Air Force, is evaluating some of those boron-treated low-alloy steels that may be satisfactorily substituted for the 4130, 4140, 8630, 8740, and 4340 steels used in many aeronautical applications. On the basis of information available at the time the program was begun, 80B30 was selected as a possible substitute for 4130 and 8630, 81B40 for 4140 and 8740, and 86B45 for 4340. The results on 80B30 have already been published in *Iron Age* for June 26, 1952 (and some of the important findings will be noted in this text, even though it is primarily devoted to tests on 86B45).

In summary, our findings on 86B30 are that it has as good impact as when normalized, although its tensile properties (normalized) are appreciably lower. Quenched and tempered, the properties of the two steels are so similar that 86B45 appears to have much promise as a substitute for 4340, thus conserving the very scarce nickel. The fabrication of small parts of not too critical a nature for testing under flight conditions appears to be warranted.

Grateful acknowledgment is made of the cooperation of D. H. Ruhnke and E. S. Bower of Republic Steel Corp. in making this steel available, and of the assistance of personnel

Table I – Chemical Composition of 86B45 Steel Under Test

Element	A.I.S.I. TS 86B45	Steel Under Test		
		Ladle Analysis	Bar Analysis	A.I.S.I. TS 86B45?!
Carbon	0.43 to 0.48%	0.46%	0.49%	0.42 to 0.50%
Manganese	0.75 to 1.00	0.94	0.89	0.70 to 1.05
Silicon	0.20 to 0.35	0.30	0.30	0.20 to 0.35
Nickel	0.40 to 0.70	0.56	0.52	0.35 to 0.75
Chromium	0.55 to 0.75	0.60	0.61	0.50 to 0.80
Molybdenum	0.08 to 0.15	0.12	0.14	0.08 to 0.15
Sulphur	0.04 max.	0.027	0.03	0.04 max.
Phosphorus	0.04 max.	0.018	0.014	0.04 max.
Aluminum	–	–	0.05*	–
Boron	0.0005 min.	0.0009	0.0008*	0.0005 min.
Vanadium	–	–	0.04 to 0.08*	–

*Values determined spectrographically.

Hardenability Tests on Boron Steels

of the Materials Laboratory of Wright Air Development Center in the test program.

Steel Tested – 1¼-in. round bars of 86B45 were furnished by Republic Steel Corp. While this heat was not produced as "aircraft quality", it is believed that the test results will indicate what can be expected from minimum aircraft quality steel.

Ladle analysis and the analysis made on the bar in this laboratory agree reasonably well (Table I), and the steel is within the limits established by the A.I.S.I. (list dated March 25, 1952) for TS 86B45 steel. Note that molybdenum is near the top of the range and that carbon in the bar analysis is one point over the specification, although within the two-point permissible check variation. The analysis is also within the standard range for TS 86B45H although this steel was not purchased to any hardenability requirement. The stock was normalized 1 hr. at 1600° F. and air cooled before being used for any subsequent tests.

Quenching Temperature – To determine the optimum quenching temperature for this steel, duplicate hardenability specimens were end-quenched from 1500, 1550, 1600 and 1650° F. The results in Fig. 1 clearly show that 1500° F. is too low, and that the difference between the other three is not great. Since 1600° F. gives somewhat better hardenability, it was used as the austenitizing temperature. The austenitic grain size was A.S.T.M. No. 8, and finer when testing by the carbon oxidation method (Method C of Federal Specification QQ-M-151).

Hardenability – The hardenability curve, end-quenched from 1600° F., has the same shape as the top of the A.I.S.I. band for TS 86B45H steel (Fig. 2). Hardness of our steel bars (full line in Fig. 2) is slightly below the top of the band for TS 86B45H at distances up to ½ in. from the end of the Jominy specimen, but slightly greater at further distances. Comparing our steel bars to the top of the band for 4340H (dashed line in Fig. 2), 86B45 is one to two points harder on the Rockwell C scale except 5/16 to 14/16 from the quenched end, wherein the two curves practically overlap.

[In the *Iron Age* article referred to above it was stated that the 80B30 bars we tested, end-quenched from 1600° F., had hard-

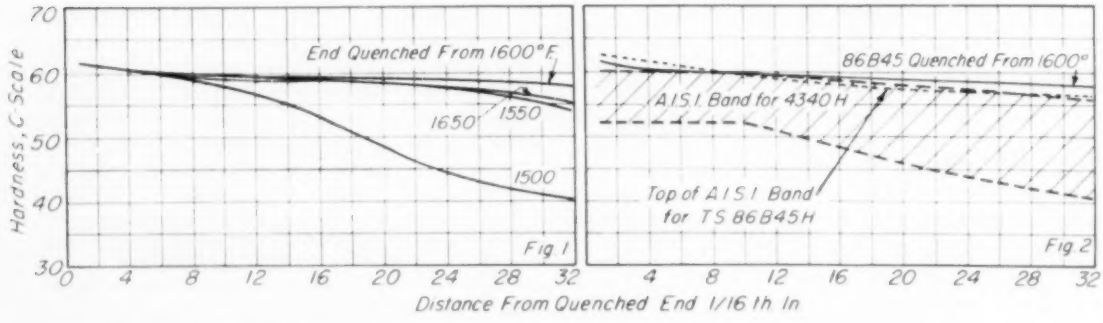
Table II – Tensile Properties of 86B45
(Data for 4340, *in italics*, from various steel companies)

Treatment	Yield*	Ultimate	Elong.	R.A.	Hardness
Normalized	107,000	157,000	11%	31%	C-31
4340	*145,000*	*205,000*	*22*	*40*	<C-45
Oil quenched (O.Q.)	224,000	351,000	9	26	C-58
Water quenched (W.Q.)					
Stress relief: 300° F., 3 hr.	209,000	349,000	9	25	C-60
Stress relief: 350° F., 66 hr.	228,000	310,000	10	37	C-55
O.Q., Tempered 600° F.	241,000	270,000	8	39	C-52
4340	*230,000*	*250,000*	*10*	*40*	*C-51*
W.Q., Tempered 600° F.	236,000	267,000	10	43	C-51
O.Q., Tempered 800° F.	208,000	221,000	9	42	C-46
4340	*200,000*	*212,000*	*10*	*45*	*C-46*
O.Q., Tempered 1000° F.	162,000	174,000	13	48	C-37
4340	*160,000*	*175,000*	*12*	*52*	C-39
W.Q., Tempered 1000° F.	161,000	172,000	12	49	C-38
O.Q., Tempered 1250° F.	116,000	129,000	18	56	C-27
4340	*115,000*	*132,000*	*20*	*62*	C-29

*At 0.2% offset.

Fig. 1 – End-Quenched Hardenability Curves for 86B45, Quenched After 1 Hr. at Indicated Temperatures

Fig. 2 – Comparison of Jominy Hardenability Curves for 86B45 With Hardenability Band of 4340H



nesses in the upper part of the published A.I.S.I. bands for 4130H and 8630H (which are almost identical) up to 7/16 from the quenched end, but then fell off, reaching the lower limit of those bands at 20/16.]

Tensile Properties — Tests on specimens heat treated in ¾-in. round sections and subsequently machined to 0.505-in. tensile specimens are given in Table II. (Corresponding values for 4340, taken largely from "Republic Alloy Steels" are shown in *italic* figures.) All bars were normalized 1 hr. at 1600° F. prior to heat treatment. Quenched bars were held at 1600° F. for 1 hr. before quenching. Tempered bars (1 hr. at temperature) were air cooled. Tabular figures represent averages for three.

As would be expected in a boron-treated steel, the properties of the normalized steel are appreciably less than those of the usual low-alloy steels of comparable hardenability.

On oil quenching, reasonably good ductility coupled with very high tensile strength is obtained. Similar results are apparently obtained with water quenching but quench cracking spoiled so many specimens we could not determine these values accurately. It is interesting to note that, although the 600° F. temper reduces the tensile strength considerably, it only slightly increases the yield strength and reduction in area. (This 600° temper hardly changes the ultimate strength, elongation and reduction of area of oil quenched 80B30 and increases the yield strength much more than a similar treatment given the 86B45 steel, as shown in Table III.)

Up to the 200,000-psi. tensile strength level the mechanical properties of both 86B45 and 80B30 fall within the scatter bands predicted by W. G. Patton in his article in *Metal Progress* for May 1943 for the most probable mechanical properties of tempered martensite. The elongation and reduction in area values for 86B45 fall toward the minimum of the band.

Military Specification MIL-S-5000 for 4340 steel requires 150,000 to 175,000 psi. tensile strength, 130,000 psi. minimum yield strength, 14% minimum elongation, and 53% minimum reduction in area in sections up to 3 in. in least dimension.

Tensile Properties of 80B30 and 86B45

With a 1000° F. temper, this 86B45 steel in ¾-in. section gave 173,000 psi. tensile, 162,000 psi. yield, 12.5% elongation, and 49% reduction in area. Under the most unfavorable condition (tensile strength near the maximum of the specified range) the ductility of this steel is not sufficient. However, the yield is well above the specified minimum and it appears that a higher tempering temperature would readily give ductility sufficient to meet the specification minimum without too much reduction in yield strength.

(As can be seen from the last five lines in Table III, 80B30 parallels neatly the military specification requirements for 4130 and 8630 at a hardness level of C-30 to 32.)

Notched Tensile Strength — In Table IV the notched and unnotched tensile properties at two tensile strength levels (220,000 to 230,000 psi. and 260,000 to 270,000) are compared with those of 4340 steel heat treated to the same strengths to determine the relative tendencies toward embrittlement in the presence of stress raisers. The test specimens were threaded on their ends and had a gage length of 2 in., a gage-length diameter of 0.555 in., and a notch 0.25 in. deep midway in the gage length. The notch had an included angle of 60° and a 0.010-in. radius at the bottom. Notched specimens were pulled in the same manner as the unnotched conventional specimens.

No great difference in notch ductility (per

Table III — Tensile Properties of 80B30*

(Heat treated in ¾-in. rounds; normalized 1 hr. at 1650° F.; austenitizing temperature 1625° F., 1 hr.; air cooled from tempering)

Treatment	Yield†	Ultimate	Elong.	R.A.	Hardness
Normalized	57,000	87,000	27	57	B-86
Oil quenched (O.Q.)	152,000	218,000	13	50	C-49
Water quenched (W.Q.)	178,000	251,000	13	50	C-51
O.Q., Tempered 600° F.	191,000	214,000	12	54	C-48
4130	*203,000*	*217,000*	*12*	*45*	*C-46*
8630	*205,000*	*215,000*	*11*	*43*	*C-47*
O.Q., Tempered 800° F.	170,000	175,000	13	56	C-41
4130	*172,000*	*188,000*	*14*	*50*	*C-41*
8630	*172,000*	*185,000*	*13*	*48*	*C-41*
O.Q., Tempered 1040° F.	126,000	136,000	20	62	C-32
4130	*125,000*	*143,000*	*18*	*59*	*C-31*
8630	*125,000*	*143,000*	*18*	*57*	*C-32*
W.Q., Tempered 1040° F.	126,000	135,000	19	62	C-30
Specified for C-30 to 32‡	**126,000**	**136,000**	**20**	**60**	**C-31**

*Data for 80B30 from *Iron Age*, June 26, 1952. Data for 4130 and 8630 *(in italic figures)* from "Republic Alloy Steels", 1949 edition.

†At 0.2% offset.

‡Military specifications MIL-S-6758 for 4130 and MIL-S-6050 for 8630.

Susceptibility to Temper Brittleness

cent reduction in cross section at the root of the notch) exists between 86B45 and 4340 at either strength level. (The existing difference is in favor of the boron-treated steel – as was likewise found in the comparison between 80B30 and 8630 in the bottom portion of Table IV.) For the notch used, the notch strength ratios are the same for 86B45 and 4340 at equal strength levels, and the ratio decreases only slightly (from 1.14 to 1.08) on going to the higher strength level. These findings indicate that the notch sensitivity of 86B45 is similar to that of 4340, and that 80B30 is practically equal to 8630 in notch sensitivity.

Notch impact values of the boron-treated steels, as determined by breaking V-notch Charpy specimens at various temperatures, are of considerable interest (Fig. 3 and 4). Each point represents the average of three individual tests. The specimens were heat treated in sizes only slightly larger than the 0.394-in. squares used for the impact specimens. Because of the relatively rapid rate of cooling obtained on these small specimens, and the high hardenability of the 86B45 steel, it is believed that the structure of these specimens contains more than 90% martensite, although this was not proven by actual metallographic examination.

The impact values obtained on 86B45 are compared in Table V with published values for 4340 steel at similar hardness levels. In the normalized condition, no significant difference in impact properties of the two steels is noted, although the 4340 is considerably harder. For the 800 and 1000° F. temperings, giving Rockwell C-46 to 48 and 38 to 40 respectively, the impact strengths of 86B45 do not vary significantly from those of 4340 steel heat treated to the same hardness level.

Temper brittleness may be inferred from the superior impact values at all testing temperatures for those specimens water quenched after tempering at 1000° F. (fifth line in Table V and graph A in Fig. 3) and specimens furnace cooled from the same temperature (seventh line in Table V and graph B in Fig. 3).

The double tempering of the 86B45 (water quenched from 1150 and air cooled after 4 hr. at 950° F.) which produced a hardness level of Rockwell C-32 to 34 is also intended primarily

Table IV – Plain Versus Notched Tensile Tests at High Strength Levels

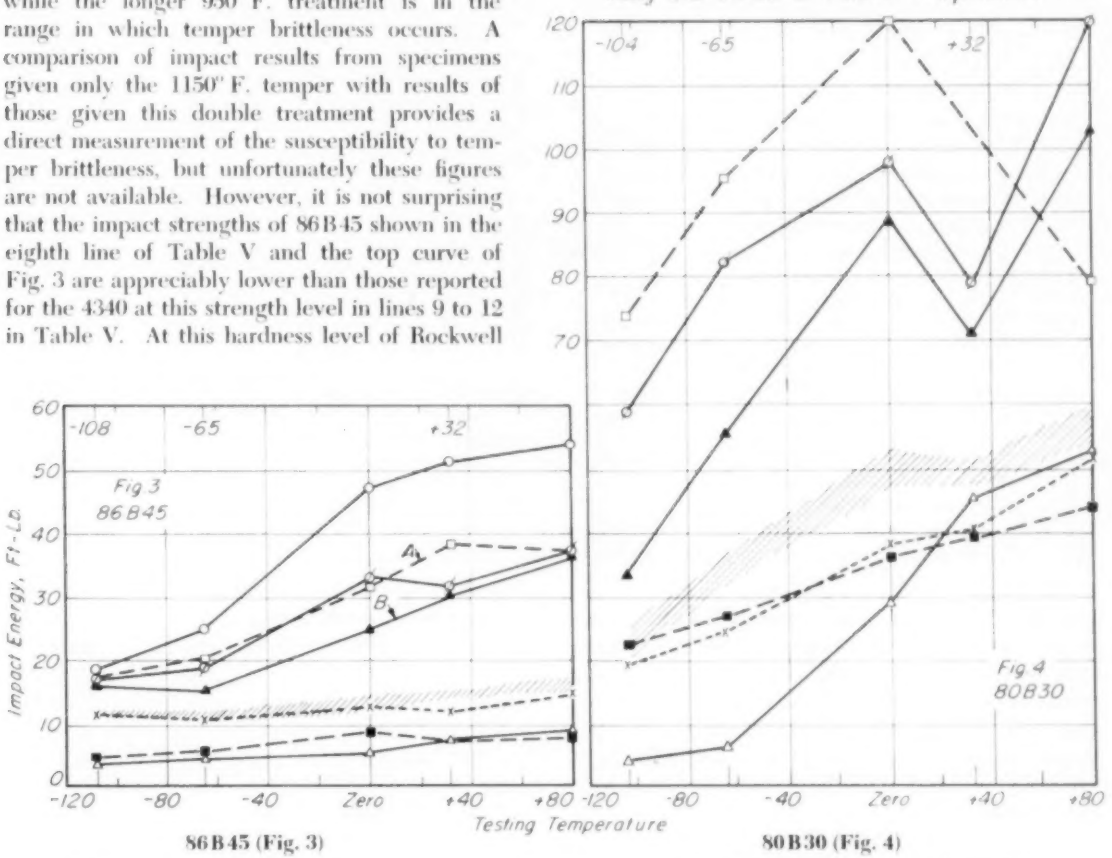
Steel	Treatment	Variety	0.02% Yield	Ultimate	Elong.	R.A.	Hardness	Notch Strength Ratio
		86B45 Versus 4340 at 260,000 to 270,000 psi.						
86B45	A	Unnotched	241,000	270,000	8	39	C-52	1.08
		Notched	– *	291,000	1	4.5	C-52	
4340	B	Unnotched	239,000	267,000	9	43	C-52	1.08
		Notched	– *	288,000	1	3.0	C-52	
		86B45 Versus 4340 at 220,000 to 230,000 psi.						
86B45	C	Unnotched	208,000	221,000	9	42	C-46	1.14
		Notched	248,000	252,000	1.5	4	C-47	
4340	D	Unnotched	213,000	224,000	9	44	C-47	1.13
		Notched	– *	254,000	1	3.5	C-47	
		80B30 Versus 8630 at 200,000 to 220,000 psi.						
80B30	E	Unnotched	191,000	214,000	12	54	C-48	1.19
		Notched	– *	255,000	2	6	C-48	
8630	F	Unnotched	166,000	202,000	10	44	C-46	1.16
		Notched	– *	234,000	2	3	C-46	
		80B30 Versus 8630 at 170,000 to 180,000 psi.						
80B30	G	Unnotched	170,000	175,000	13	56	C-41	1.20
		Notched	202,000	210,000	2.5	8	C-41	
8630	H	Unnotched	153,000	174,000	12	47	C-42	1.16
		Notched	189,000	202,000	4	9	C-42	

* No stress-strain curves recorded.

Heat treatments – A: Normalized 1 hr. at 1600° F., austenitized 1 hr. at 1600° F., oil quenched, tempered 1 hr. at 600° F., air cooled. B: Normalized 1 hr. at 1600° F., austenitized 1 hr. at 1525° F., oil quenched, tempered 1 hr. at 575° F., air cooled. C: Same as A except tempered at 800° F. D: Same as B except tempered at 790° F. E: Normalized 1 hr. at 1650° F., austenitized 1 hr. at 1625° F., oil quenched, tempered 1 hr. at 600° F., air cooled. F: Normalized 1 hr. at 1650° F., austenitized 1 hr. at 1575° F., oil quenched, tempered 1 hr. at 550° F., air cooled. G: Like E, except tempered at 800° F. H: Like F, except tempered at 800° F.

to show temper brittleness. In this double treatment the 1150° F. temper reduces the hardness, while the longer 950° F. treatment is in the range in which temper brittleness occurs. A comparison of impact results from specimens given only the 1150° F. temper with results of those given this double treatment provides a direct measurement of the susceptibility to temper brittleness, but unfortunately these figures are not available. However, it is not surprising that the impact strengths of 86B45 shown in the eighth line of Table V and the top curve of Fig. 3 are appreciably lower than those reported for the 4340 at this strength level in lines 9 to 12 in Table V. At this hardness level of Rockwell

Fig. 3 and 4 – Notched Charpy Impact Tests on 86B45 and 80B30 Heat Treated Variously and Tested at Various Temperatures



86B45 (Fig. 3)

Hardness	Heat Treatment*	Legend	Heat Treatment*	Hardness
C-32 to 34	Normalize (1600)		Normalize (1650)	B-83 to 87
C-60 to 62	Oil Quench (1600)		Oil Quench (1625)	C-48 to 50
C-52 to 54	O.Q.; T. 600; A.C.		O.Q.; T. 600; A.C.	C-46 to 48
C-46 to 48	O.Q.; T. 800; F.C. or W.C.		O.Q.; T. 800; F.C. or W.C.	C-39 to 41
C-38 to 40	O.Q.; T. 1000; A.C.		T. 1040; A.C.	C-30 to 32
C-38 to 40	O.Q.; T. 1000; F.C.		T. 1040; F.C.	C-30 to 32
C-39 to 40	O.Q.; T. 1000; W.Q.		T. 1040; W.Q.	C-31 to 32
C-32 to 34	Double Temper†		No data	

80B30 (Fig. 4)

*O.Q. = oil quench; T. = temper; A.C. = air cooled; W.Q. = water quenched, F.C. = furnace cooled.

†Oil quenched; tempered 1 hr. at 1150° F.; water quenched; re-tempered 4 hr. at 950° F.; air cooled.

C-30 to 32, the published data for 4340 quoted indicate that it also may be somewhat susceptible to temper brittleness, since the impact values of the oil quenched specimens (line 10) are definitely higher than when furnace cooled (line 11).

E. S. Rowland of the Timken Roller Bearing Co. reported at a meeting of the Technical Committee on Boron Steels of the Society of Automotive Engineers on Dec. 4, 1951, on the impact properties at room temperature of some tentative standard and boron-treated steels tempered in the 950 to 1100° F. range. His results give additional information on the effects of tempering in this range, although direct comparisons cannot be made since no data on 86B45 steel were included.

If 86B45 steel is used as a substitute for 4340, many of the applications will be in the 180,000-psi. tensile strength range. With the 1000° F. temper used in these tests to get this strength level (Rockwell C-38 to 40) there is a susceptibility to temper brittleness (compare lines A and B in Fig. 3), but this difference is not great and it appears that parts made of this steel and requiring this tensile strength level would not be adversely affected by temper

Table V – Comparative V-Notch Charpy Impact Properties of 86B45 and 4340 Steels

Steel	Condition	Cool From Tempering	Source†	C-Scale Hardness	Ft-Lb. Impact at:				
					Room	32° F.	0°	−65°	−108°
86B45	Normalized	—	A	32 to 34	9	7	6	5	4
4340	Normalized	—	B	*45*	*12.4*	*7.5*‡	—	*6.6*§	*4.8*¶
86B45	Quenched; Tempered 800° F.	Water	A	46 to 48	17	15	14	11	11
4340	Quenched and Tempered	Water	C	*49*	*15*	*14*	*13*	*12*	*11*
86B45	Quenched; Tempered 1000° F.	Water	A	39 to 40	37	38	32	20	17
4340	Quenched and Tempered	Water	C	*40*	*38*	*36*	*35*	*29*	*22*
86B45	Quenched; Tempered 1000° F.	Furnace	A	38 to 40	36	30	25	15	16
86B45	Double Tempered*	Air	A	32 to 33	54	51	47	25	18
4340	Quenched and Tempered	Water	C	*31*	*72*	*72*	*72*	*68*	*56*
4340	Quenched and Tempered	Oil	D	*30 to 31*	*85*	*80*	*77*	*70*	*67*
4340	Quenched and Tempered	Furnace	D	*30 to 31.5*	*73*	*70*	*67*	*62*	*47*
4340	Quenched and Tempered	Unknown	B	*29.2*	*82*	*82*‡	—	*88*§	*78*¶

*First tempering: 1 hr. at 1150° F., water quenched; second tempering: 4 hr. at 950° F., air cooled.

†Source: A. This investigation.

B. A. J. Herzig and R. M. Parke, "Low Temperature Impact Properties of Some S.A.E. Steels", *Metals and Alloys*, Vol. 9, 1938, p. 90-93.

C. M. Baeyertz, W. F. Craig, Jr., and J. P. Sheehan, "Effect of Alloying Elements on Impact Properties of Quenched and Tempered Steels", Armour Research Foundation Report No. 22, Illinois Institute of Technology, Sept. 1, 1949.

D. "Low Temperature Properties of Ferrous Materials", SP-65, Society of Automotive Engineers, 29 West 39th St., New York, N. Y., 1950.

‡At 14° F. §At −40° F. ¶At −94° F.

brittleness phenomena, since the cooling rate used in our laboratory furnace is slower than those which exist in relatively large parts cooling in air from a conventional tempering treatment. A greater susceptibility to temper brittleness would be expected if quenching practice or large section size made it necessary to temper the parts at a slightly lower temperature.

Comparison with the impact properties of 80B30 steel in Fig. 4 shows that the impact properties of the 86B45 steel are much lower at a given hardness level and testing temperature. Obviously, one major cause of this is the higher carbon content of the 86B45 steel. However, the latter does not show the sharp drop in impact strength between room and subzero temperatures observed for the 80B30 steel at the Rockwell C-30 to 32 hardness level (top three lines in Fig. 4). This makes the explanation of the phenomena in the 80B30 steel still more difficult since both are boron-treated steels containing the same three principal alloying elements – nickel, chromium, molybdenum – although in different amounts.

Although the impact tests have not been conducted over a sufficient temperature range to determine accurately the so-called "transition temperatures" for the various treatments, Table VI lists approximations based on an estimation of the lowest temperature at which the fracture remains fibrous.

The solution used for the detection of temper brittleness (picric acid in ether with Rodalon wetting agent) shows no significant difference in the amount of attack on the quenched and tempered specimens of 86B45 with the exception of the specimen given the double temper at 1150 and 950° F., which was attacked appreciably greater – indicating, but not conclusively proving, a susceptibility to temper brittleness produced by this heat treatment.

Fractures of the broken tensile specimens of 86B45 are usually of the conventional cup and cone type. Only for the higher tempering temperatures (1000 and 1250° F.) is the fracture of the star type, as was found in a number of the 80B30 steel samples tempered at 800° F. and above. In no case does the 86B45 show the extreme "split" type of fracture observed in some of the 80B30 specimens. This star type of fracture may be transitional between the desirable "cup and cone" and the undesirable "split" fracture. It is of interest to note that the specimen of 4340 steel tempered at 800° F. showed a fracture intermediate between the conventional cup and cone type and the star type.

Table VI – Approximate Transition Temperatures
(Tough to Brittle Fracture)

Condition	86B45	80B30
Normalized	>70° F.	>70° F.
Oil quenched	>70	+32
Drawn 600° F.	>70	+32
Both 800° draws	>70	0
All 1000° draws	+32 to −65	—
Drawn 1040°, furnace cooled	—	0
Same, air or water cooled	—	<−104
Double draw, 1150 and 950°	0 to −108	—

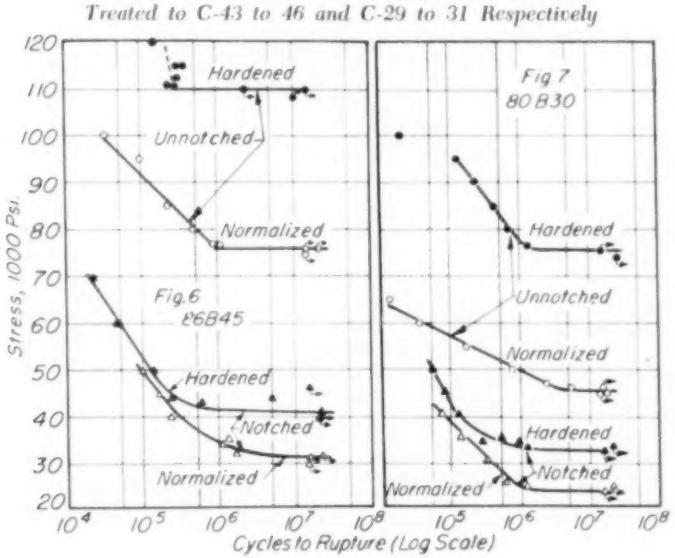
Fig. 5 – Impact Fractures of 86B45 Steel With Indicated Heat Treatments at Temperatures Shown. The actual specimen size was 0.394 in.

In the impact specimens the fractures of 86B45 are usually of the conventional fibrous or brittle types (Fig. 5). Only in the specimens tempered at 1000° F. and in those given the 1150 and 950° F. double tempering are occasional fractures of the split type observed. Even when the split-type fracture occurs, it is not nearly as severe as those found in the 80B30 steel, drawn at 800 or 1040° F. In our tests on 80B30 the exaggerated split fractures were associated with lower energy absorption than those with the same history but which broke with the usual ductile fibrous appearance.

The significance of this type of fracture is still not clear, although the appearance of the fractures is similar in character, but not as extreme as those obtained by Lea and Arnold on severely embrittled tensile specimens of nickel-chromium steel. (See "Temper Brittleness" by John H. Hollomon, *Transactions* ASM, 1946, p. 473.) If the split-type fracture is an indication of susceptibility to temper brittleness, the 86B45 steel would be rated as less susceptible to temper brittleness than the 80B30.

Rotating beam fatigue strengths of 86B45 steels were determined on notched and unnotched standard specimens $3\frac{7}{16}$ in. long, as normalized and as quenched and tempered. Unnotched specimens had a radius of 5 in., with a smallest section diameter of 0.290 in. The notched specimens had a diameter of 0.340 in. with a notch 0.025 in. deep which had a 60° included angle and a 0.010-in. radius at the bottom. The strength reduction ratios for the normalized and heat treated conditions are 2.45 and 2.68.

Fig. 6 and 7 – Endurance Limits for 86B45 and 80B30, Notched and Unnotched, Annealed and Heat Treated to C-43 to 46 and C-29 to 31 Respectively



As shown in Fig. 6, the endurance limit of normalized 86B45 is 76,000 psi. in unnotched samples and 31,000 psi. in notched samples; the ratio one to the other is 2.45. For samples heat treated to C-43 to 46 hardness, the endurance limit is 110,000 psi. in unnotched samples and 41,000 psi. in notched samples; the ratio one to the other is 2.68.

Figure 7 for 80B30 shows that its endurance limit in normalized condition is 45,000 psi. in unnotched samples and 23,000 in notched samples; the ratio one to the other is 1.95. For samples heat treated to C-29 to 31 the endurance limit is 76,000 unnotched and 32,000 notched; the ratio is 2.37.

As is usual, the unnotched endurance limits are approximately 50% of the tensile strength and fall well within

bands representing the usual endurance limit expectancy for notched and unnotched plain and alloy steels.

In evaluating the results of these tests, it must be emphasized that only one heat of each steel was tested and that similarity in Jominy end-quench hardenability curves is not necessarily the only requirement for one steel to serve as an adequate substitute for another steel.

COMMENTARY

The caution concerning the results on a single heat is especially important. Chemical analysis shows that important alloying elements in the 86B45 are at or above the middle of the specified range and that carbon and molybdenum are at the very top. A significant amount of vanadium is also present. Some seem to believe that the presence of vanadium is of special advantage in the boron-treated steels and it may be that this is one of the factors contributing to the steel's very high hardenability. In any event, the hardenability is higher than that of 4340H, and for distances more than ¾ in. from the quenched end is slightly higher than the maximum for the TS 86B45H band.

Available data on 14 production heats of 86B45 indicate that the hardenability values tend to be close to the top of the A.I.S.I. band for the first ¾ in. from the quenched end and then to drop off and scatter out. It therefore appears that the heat on which these present data were obtained represents maximum hardenability and that the results reported probably represent the best that can be expected with this steel. Properties obtained on average heats of 86B45 will probably be somewhat lower than the data cited.

To summarize the findings, the mechanical properties of 86B45 specimens in the normalized condition are appreciably lower than those of 4340. It is interesting to note, however, that the impact properties of the two steels in the normalized condition are not significantly different.

In the quenched and tempered condition, the properties obtained on 86B45 are generally comparable with those of 4340. The notch sensitivity under the conditions investigated is very similar to that of 4340 up to the 260,000-psi. strength level. The impact properties are likewise very similar to those of 4340. Around the 180,000-psi. strength level the 86B45 appears to be slightly susceptible to temper brittleness. However, the impact strength is better than 15 ft-lb., even at —108° F., and this value would be considered adequate by many designers for general applications. These values are only slightly lower than those of 4340 for the same temperatures.

The 86B45 steel shows great promise as a substitute for 4340 steel to conserve considerable nickel and save some chromium and molybdenum. A definite conclusion as to the interchangeability of these steels cannot be drawn without additional information on the properties of heats of 86B45 of low chemistry and near minimum hardenability. It appears, however, that experimental fabrication and tests of actual aircraft parts made from this steel would likely prove that it is a satisfactory substitute for 4340 for many applications. The first work should be limited to reasonably small parts of not too critical nature, since the behavior of this steel in large cross sections has not been investigated, and since a background of service experience for the steel is lacking. Better knowledge of the characteristics of this steel is needed before its use, even on an experimental basis, could be recommended for extremely critical aeronautical applications of low margin of safety, such as landing gear struts for large aircraft.

As to 80B30, the conclusions stated in our article in *Iron Age* for June 26, 1952, are that its tensile properties when quenched and tempered to C-30 to 32 compare favorably with the minimum in military specifications for 4130 and 8630. V-notch Charpy impact values are quite good at room temperatures, but these values drop sharply with decreasing testing temperatures in normalized samples or quenched samples drawn at 1040° F., which strongly suggests a susceptibility to temper brittleness in the range around 1000° F.

On comparing notched tensile tests, the scatter in results is found to be less for 80B30 than for 8630, and its notch ductility is higher at high strength levels. Broken specimens drawn at 800 to 1250° F. often exhibit "star" or "split" fracture surfaces. Fatigue strengths of both smooth and notched test pieces fall at about the usual ratio to tensile strength of samples of equivalent treatment.

Whether the Charpy impact strength of 80B30 is adequate will depend on the service of the part. Where 10 to 20 ft-lb. is considered adequate, it is believed that 80B30 could be used at temperatures down to —100° F., except in the normalized condition.

Short Runs

Machine Arc Welding

IN ASSEMBLING the front sections of the right and left exhaust pipes for the new Buick V-8 overhead-valve engine, it was necessary to bring the two pipes together on the right-hand side of the engine and to join them securely to a $\frac{7}{16}$-in. thick stamped steel flange. Roughly triangular in shape, with rounded sides, the flange has three outer holes for bolting to the rear section of the exhaust pipe which leads to the muffler, and a 2½-in. hole to receive the two pipes from the engine exhaust ports. One pipe serves four cylinders on one side of the engine, the other the cylinders on the opposite side.

To meet production demands and to assure low cost, a special machine setup was worked out to arc weld the joint between the flange and the two pipes. For the desired fit, the 2-in. diameter pipes, of 0.076-in. wall thickness, are upset at their ends to form a semicircular cross section with 2½-in. diameter. When the two are placed with flat sides together, they form a circular cross section just fitting the flange hole (Fig. 1). The latter is chamfered slightly on the outside to make a channel for the weld. The circumferential weld (Fig. 2) is made by machine in 11 sec., while the joint between the mating faces of the pipes, across the diameter, is later hand arc welded. Both flange and pipes are S.A.E. 1010 steel, the pipe being electrically welded from hot-rolled strip.

In designing the machine setup, rigidity was a prime consideration. A locking fixture to hold the loose assembly of pipes and flange positions them securely and at the proper angle below the welding head which is mounted on the upper machine frame. An arrangement of hydraulic controls and air cylinders actuates a rack and pinion to rotate the fixture through 360° as the weld is being made, then retracts through an over-riding clutch for the next cycle.

Welding head and generator are of standard Lincoln Electric Co. designs, with modifications worked out in the control panel and in the handling and recirculation of flux to insure an adequate supply free from contamination. The machine unit was built by National Electric Welding Machine Co., and is the first of its kind. Locking fixture and its power drive, along with the control circuit, were developed by Buick engineers.

After locking the assembly in the fixture, the operator pushes a button to lower the head to welding position and to "inch" the welding wire down to where contact with the work is made. A "cycle start" button then is actuated and flux issues from a tube surrounding the electrode

Fig. 1 – Ends of Two Front Exhaust Lines Are Upset and Flattened as Shown to Fit Flange for Bolting to Rear Section. Note chamfering on edge of flange hole to form groove for weld metal

Fig. 2 – Appearance of the Circumferential "Hidden Arc" Weld, Made by Machine in 11 Sec. Straight joint between the two pipes is sealed later by manual arc welding

for an instant before the fixture begins to rotate and the welding action starts.

The welding current is approximately 300 amps. at 24 volts. Welding wire is $\frac{3}{32}$-in. mild steel, copper coated, and is fed from an overhead reel into the rolls of the welding head.

Excess flux falls into a vibrating hopper in the base of the machine where a screen separates the small particles of slag from the flux. A bucket elevator carries the reclaimed flux to an overhead hopper above the machine from which it is supplied to the weld as needed.

Since the arc and molten metal in the joint are blanketed by flux at all times, the weld metal is cleaned and protected from contact with the air during solidification. This assures weld soundness and makes possible the use of exceptionally high amperage for fast welding and lower cost. The attendant avoidance of spatter further eliminates the need for weld cleaning. With the arc submerged in flux, there is no arc flash and practically no smoke.

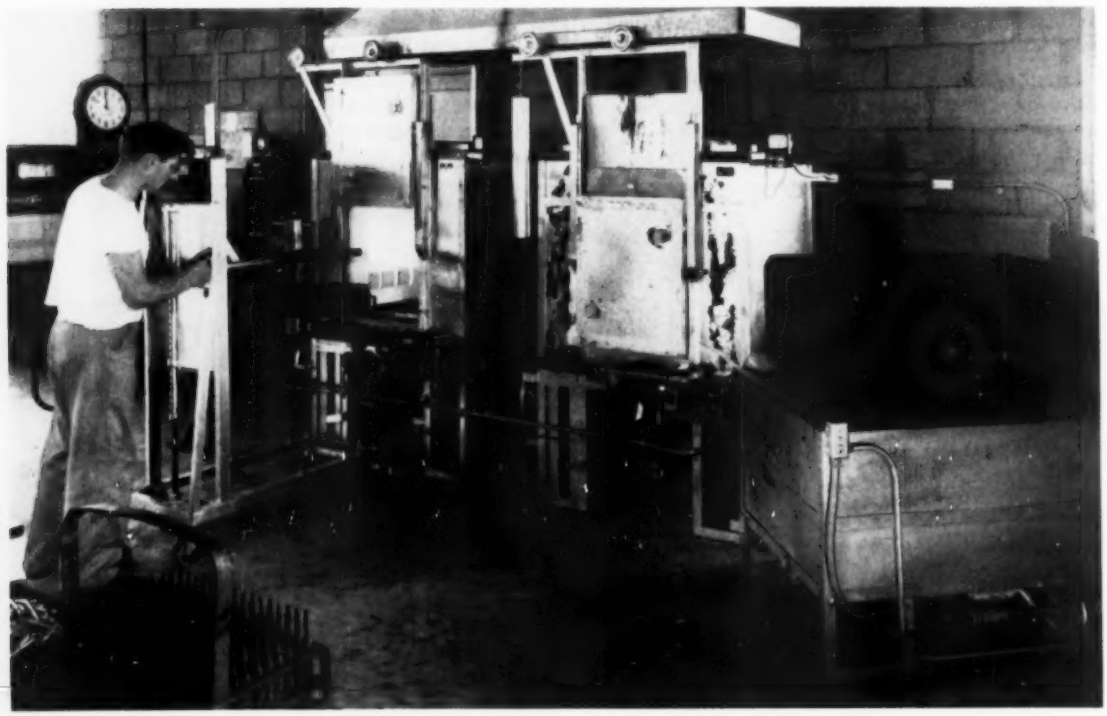
Heat Treating Aids

When Oceana Tool Mfg. Co. Inc., Venice, Calif., set up its heat treating department for the router bits it produces, special jigs were designed for use with the small fork-lift furnace loader shown in front of the operator in Fig. 3. Not only is the transfer of tool racks expedited with the hand-operated loader, but fewer baskets of heavier loads can be charged into the furnaces.

Two 5-cu.ft. "Contro-Therm" furnaces, made by A. D. Alpine, Inc., are used, either of which can be employed for preheating, hardening or drawing at temperatures up to 2500° F. The furnaces are operated with a normal atmosphere after it was determined that an atmosphere cartridge was not needed to prevent carburization or decarburization. As many as 1600 tools have been run through the furnaces in a 24-hr. period.

The router bits, of high speed toolsteel, require good toughness in the shank (Rockwell C-47) and high hardness in the flute (Rockwell C-57). These divergent hardness requirements necessitate a smooth hardness transition to avoid creation of a shatter point. The tools are used at speeds exceeding 3500 r.p.m.

Fig. 3 – Furnaces for Preheat and Draw at Left, High Heat at Right. Extreme right is quench tank with self-contained circulating equipment



By R. L. RICKETT, Research Laboratory, United States Steel Corp., Kearny, N. J., and
A. O. MASON, Vibration Fatigue Laboratory, American Steel and Wire Division, U. S. Steel Corp.*

The endurance limit of austempered springs was found to be practically the same as for springs of the same tensile strength made from "oil tempered" (pretempered) wire and for quenched and tempered or marquenched and tempered springs. At the same tensile strength, however, proportional limit of the austempered springs is lower, and hence their tendency to set under high loads is greater. If the proportional limit of the austempered springs is raised to that of the oil tempered wire, by austempering to a higher hardness and tensile strength, the endurance limit is increased. The same trends were found for specimens of wire tested in reversed bending.

Fatigue Properties of Springs as Affected by Heat Treatment

THE LIMITED DATA available on endurance limit of austempered carbon or low-alloy steel specimens, ground and polished after heat treatment, indicate that this method of heat treatment results in about the same endurance limit as does quenching and tempering to comparable hardness or tensile strength. Fatigue data of this sort, however, are not always sufficient to predict the effect of austempering on the performance in actual service of parts subjected to alternating or fluctuating loads. Such parts may be partially decarburized in heat treatment and in many instances they do not have a smooth surface; these and other factors not present in conventional laboratory tests may alter considerably the relative effect of different methods of heat treatment on fatigue properties. The present investigation was undertaken as a result of numerous requests for information on the fatigue behavior of austempered parts, and particularly to obtain data on the comparative fatigue properties of springs heat treated by austempering or by other commonly used methods.

Material and Specimen Preparation – Cold drawn wire from a heat of steel made to fine-grain practice (deoxidized with silicon and aluminum) and valve-spring quality was used. Composition of this steel was 0.65% C, 0.72% Mn, 0.013% P, 0.019% S and 0.25% Si.

A wire diameter of 0.135 in. was selected for this investigation to insure that the springs could be austempered properly to optimum properties – a requirement which limits the section that can be treated by this process.

A portion of the cold drawn wire was heat treated to a hardness of Rockwell C-47 to 48 by a continuous process commonly used in the spring-wire industry. This will be referred to as "oil tempered" wire; it is sometimes called pretempered wire. Helical springs designed to fit the available fatigue testing apparatus were coiled from this oil tempered wire. These springs (1.25 in. in outside diameter, with 4½ turns per in. of length) were then stress-relieved at 600° F. for 30 min., a treatment that had been found by experience to give the best static properties at ordinary temperatures.

Other springs coiled from the same lot of cold drawn wire, together with straight lengths of the wire, were heat treated in the Laboratory, precautions being taken to minimize decarburization and distortion. Despite these precautions slight partial decarburization occurred, to a maximum depth of 0.010 in., and it was impossible to avoid distortion completely. It is believed, however, that the comparison value of the results was not affected.

*The authors are particularly indebted to their associates, J. C. Little (now with Preformed Line Products Co., Cleveland), L. A. Luini (now with Wright Aeronautical Co., Wood-Ridge, N. J.), and H. J. Elmendorf, for their help.

Fatigue Tests on Springs

The heat treatments used included conventional oil quenching and tempering, marquenching and tempering, and austempering. The treatments were intended, first, to afford a comparison of endurance limit at the same level of tensile strength as the oil tempered wire. Because it was known that austempering results in a lower proportional limit for the same tensile strength, other specimens were austempered to a higher tensile strength so that a comparison with the oil tempered wire could also be made at the same proportional limit. The marquenched and tempered specimens also were heat treated to two levels of tensile strength and hardness. The treatments and resulting properties are listed in Table I.

The heat treated springs and those made from oil tempered wire were all shot-peened under the same condition. This was done so that all would have a comparable surface, regardless of the heat treatment employed, and also to obtain the best possible fatigue properties. It was not considered feasible to shot-peen the straight lengths of wire in the equipment that was available.

Fatigue Test Procedure – The helical springs were tested in pulsating tension with the stress (torsional) in the wire ranging from a minimum of 5000 psi. to a selected maximum. The load required to produce the desired stress was calculated from the spring formula:

$$P = \frac{\pi S d^3}{8D}$$

where P = load in pounds, S = stress in psi., d = diameter of wire in inches, D = mean spring diameter in inches. The values of P were then corrected for curvature of the wire by using the appropriate Wahl correction factor.

The springs were first pre-set by applying a load slightly greater than the maximum to be used in the fatigue test. The deflections corresponding to the minimum stress of 5000 psi. and to the maximum stress to be used were then measured by applying, with a platform scale, the required loads computed by means of the foregoing equation. The springs were then placed individually in a crank-operated reciprocating fatigue tester which was adjusted so that the springs were in tension and the stress pulsated between a minimum of 5000 psi. and the desired maximum. Design of the machine is such that if the springs had set during test so as to lower the imposed stress by as much as 5000 psi. the machine would have shut off. Since this did not occur, it is known that the stress range did not change by as much as 5000 psi. The tests were continued for 20,000,000 cycles unless the springs broke.

Specimens of heat treated wire were tested in reversed bending, using a rotating-strut type of machine. Maximum fiber stress in the wire was computed from the formula:

$$S = \frac{\pi^2}{360} \times E \times d \times \frac{\theta}{L}$$

where S = stress in psi., E = modulus of elasticity in psi., d = diameter of wire in inches, L = active length of wire in inches, and θ = deflection in degrees. These tests were continued only up to 10,000,000 cycles.

Test Results – S-N diagrams for the shot-peened springs are shown in Fig. 1 and for the wire specimens in Fig. 2. Results of both sets of tests show considerable scatter, some of which is probably due to differences in amount

Table I – Heat Treatment and Properties of Spring Wire

Treatment[1]	Rockwell Hardness C-Scale	Tensile Strength[4]	Proportional Limit	Elongation in 10 In.	Reduction of Area	Proportional Limit (Torsion)[5]
Oil tempered and blued at 600° F.	47-48	230,000 psi.	204,000 psi.	5.7%	63.0%	147,000 psi.
Quenched and tempered[2]	46-47.5	228,500	197,200	4.8	42.3	141,000
Marquenched[3]						
Tempered at 705° F.	48.5-49	238,700	201,200	4.4	48.7	146,500
Tempered at 735° F.	47.5-48	229,500	197,200	4.8	51.7	138,000
Austempered (in salt)						
at 585° F. for 37 min.	52	265,000	200,200	3.4	49.0	160,000
at 650° F. for 19 min.	46.5-47	224,200	189,400	4.7	57.5	129,000

[1]All samples except oil tempered wire austenitized 5 min. at 1525° F.; austenite grain size 7 to 8.
[2]Quenched in oil at 145° F.; tempered 1 hr. at 735° F.
[3]Quenched in salt at 500° F., ½ min.; tempered 1 hr.
[4]Tensile tests made on 0.135-in. wire in 10-in. gage lengths.
[5]Calculated from load-deflection tests of shot-peened springs.

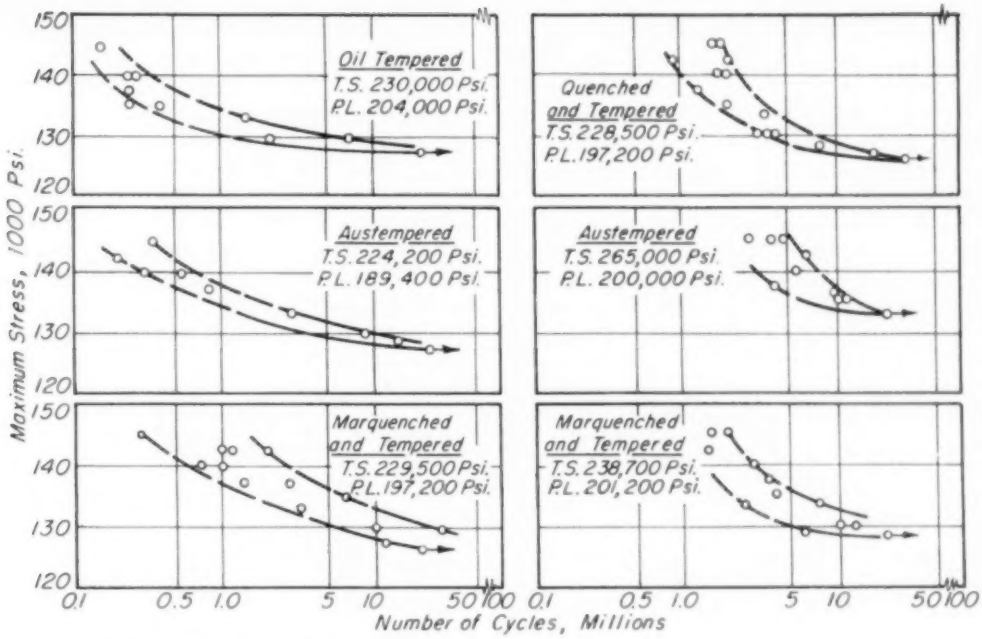
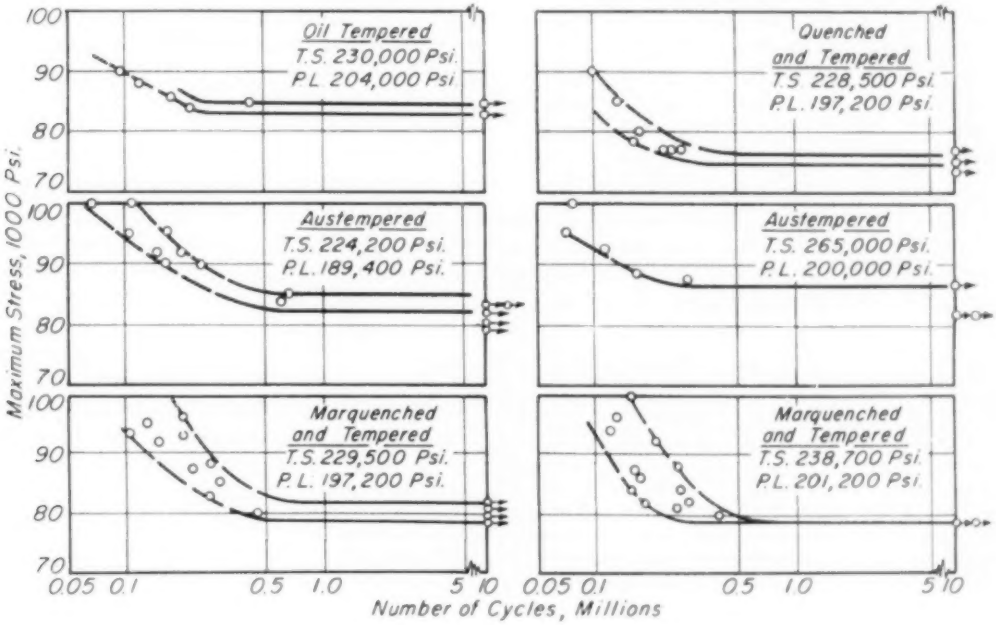


Fig. 1 – Results of Fatigue Tests of Shot-Peened Springs in Fluctuating Torsion. Stressed from +5000 psi. to maximum. Arrows indicate that specimens did not break

of distortion during heat treatment and some to random differences in surface condition of the wire. The bands in Fig. 1 and 2 indicate the range of observed values; these bands would be even wider if more tests had been made, and they might be shifted somewhat if the tests were repeated. Despite these limitations, the data are believed to show, at least qualitatively, the effect of the four methods of heat treatment on fatigue properties of valve-spring wire.

Endurance limits obtained by the four meth-

Fig. 2 – Results of Fatigue Tests of Wire (Not Shot-Peened) in Reversed Bending (Rotating Strut). Arrows indicate that specimens did not break



ods of heat treatment are listed in Table II. The values represent the lower limit of the bands in Fig. 1 and 2.

Endurance limit of the oil tempered and the austempered springs, for the same tensile strength, is about the same. Endurance limit after marquenching and tempering is slightly lower, and after quenching and tempering is still lower, but these differences are so small that they may not be significant. Above the endurance limit, the curves for quenched and tempered and for marquenched and tempered springs rise much more abruptly than the others (Fig. 1).

When heat treated to the same proportional limit, Table II shows that austempered springs have considerably higher endurance limit than the others. Such austempered springs also have a higher proportional limit in torsion (Table I) and their ductility is better than that of the quenched and tempered springs although about the same as that of marquenched and tempered and lower than that of oil tempered springs.

Shape of the S-N curves for the wire tested in reversed bending (alternating tension and compression, Fig. 2) is different than for the shot-peened springs (tested in unidirectional fluctuating torsion, Fig. 1). There are also minor differences in relative order, with respect to the endurance limit, for the various methods of heat treatment.

For the same tensile strength, Table II shows that quenched and tempered wire specimens have the highest endurance limit, with oil tempered and austempered specimens only slightly lower, and the marquenched and tempered wire definitely lower. For the same proportional limit, the austempered wire has the highest endurance limit and the marquenched and tempered wire the lowest.

The foregoing data indicate that properly austempered springs have fatigue characteristics at least equal to those of springs (of otherwise comparable properties) made from oil tempered wire or to springs heat treated by other methods after they are formed. For springs heat treated after forming, austempering yields the best combination of fatigue characteristics and ductility, marquenching and tempering is next best, and quenching and tempering results in the least desirable combination of properties.

CONCLUSIONS

Within the limitations of the data, the following conclusions may be drawn:

1. For nominally the same tensile strength (225,000 to 230,000 psi.), and when all are tested in the shot-peened condition, austempered springs have approximately the same endurance limit as springs made from oil tempered wire and stress-relieved at 600° F. The endurance limit of springs quenched and tempered or marquenched and tempered is slightly lower but probably not significantly so.

2. For approximately the same tensile proportional limit (200,000 to 204,000 psi.) but higher tensile strength, austempered springs have a definitely higher endurance limit than springs heat treated by other methods.

3. In alternating tension and compression, austempered wire has nearly the same endurance limit as oil tempered or quenched and tempered wire of the same tensile strength or same proportional limit. The endurance limit of marquenched and tempered wire is considerably lower.

4. When heat treated to the same tensile strength, or same proportional limit, oil tempered wire is the most ductile, austempered wire slightly less ductile and quenched and tempered wire least ductile. Marquenched and tempered wire is more ductile than wire quenched and tempered to the same tensile strength or proportional limit, and only slightly less ductile than wire that was austempered to the same proportional limit.

Table II – Effect of Heat Treatment Method on Endurance Limit

Heat Treatment	Endurance Limit of Springs*		Endurance Limit of Wire†	
	At Same Tensile Strength‡	At Same Proportional Limit§	At Same Tensile Strength‡	At Same Proportional Limit§
Oil tempered	128,000 psi.	128,000 psi.	83,000 psi.	83,000 psi.
Austempered	128,000	133,000	82,000	86,000
Quenched and tempered	126,000	126,000	84,000	84,000
Marquenched and tempered	127,000	128,000	79,000	79,000

*Based on 20 million cycles in pulsating extension from 5000 psi. to maximum.
†Based on 10 million cycles in alternating tension and compression.
‡225,000 to 230,000 psi. §197,000 to 204,000 psi.

Reported by HAROLD SCHOR
Tech-Industry Services
New York City

at Newark, Ohio (to be operated by Kaiser Aluminum & Chemical Co.). To make even larger aluminum forgings, a pair of hydraulic presses of 35,000 and 50,000 tons capacity have been contracted for by Aluminum Co. of America and the U. S. Air Force, and should be in operation in 1954. Presses as large as 200,000 tons are anticipated, but for them the conventional press designs would have to be abandoned.* Alcoa has also finished installation of the record-breaking 14,000-ton extrusion press at Lafayette (Ind.) works.

Metallurgical Aspects of Large Pressings, Forgings and Extrusions for Aircraft

WITH AN ATTENDANCE that surprised even its sponsors, the Symposium on Heavy Presses for Light Metal Forging and Extrusion was the standout feature of the American Society of Mechanical Engineers' annual meeting held in New York early in December. Although the meeting was arranged by the Aviation Division of the A.S.M.E., the meeting room was dominated by Air Force exhibits (and uniforms). The interest shown by the audience was not limited to aircraft applications; obviously, if the large-scale forging and extrusion of light metals will work for the aircraft industry, it should be of interest to other fields of manufacture.

It would seem that the Air Force's interest in heavy presses dates back to the discovery of extremely large hydraulic forging presses in Germany by our technical intelligence teams which closely followed the invading armies. One such machine, a 15,000-metric-ton forging press, was dismantled, and is now in operation in the United States. A 33,000-ton press was "liberated" by the Russians, and it can be assumed that it is not standing idle. The Germans used these presses to make unusually large aluminum forgings for their aircraft. Contracts have already been let in this country to E. W. Bliss Co. to build a 35,000 and a 25,000-ton press for the new Air Force plant

Aircraft forgings produced by the large presses will include beams, wing spars, bulkheads and ribs. A typical example is a spar cap formerly assembled from several components, including the root, inboard and outboard ends; it is now produced in one operation. Potential savings of metal and manufacturing time depend on the solution of a number of problems in metallurgy, which are also related to heavy press design. (Large light-metal alloy forgings may be defined as those weighing over 40 lb. or over 30 in. long. Large light-metal alloy extrusions are those over 10 sq.in. in cross-sectional area, or over 10 in. diameter, or over 100 lb. in weight.)

The following account will be confined largely to metallurgical aspects of heavy forgings and extrusions. Some notes describing the mammoth Bliss presses are presented on p. 186 of this issue.

Aircraft Requirements – The over-all prob-

*EDITOR'S FOOTNOTE: An entirely different design concept to provide presses with capacities of 75,000 tons or more has been evolved by Hydraulic Press Mfg. Co. and the Austin Co. in what is called a "throatless" press. By attaching the crown to a block of concrete which forms the roof of the structure housing the press, tie rods and push-back cylinders are eliminated and a 360° access to the work is provided. The crown contains the hydraulic rams, and the press baseplate is supported by a subfloor as in conventional designs.

Uniformity in Large Ingots

lem in the production of extruded or forged structural elements with high load-carrying efficiencies appears to be twofold. The engineer usually determines the feasibility of the particular design in terms of the orientation and configuration of the applied stress patterns. His selection of an extruded, forged, machined or cast structure usually depends upon the mechanical and physical properties available to him as a result of these particular manufacturing processes applied to suitable metals or alloys. If he is to select the integrally stiffened structure in which the skin and skin-stiffening elements are made of one part (as compared with the "bits-and-pieces" construction), it will take close cooperation between the press designer and the metallurgist to deliver parts with the desirable mechanical and physical properties. It appears that there is a rooted conviction that extruded and forged sections are superior to parts made by other conventional fabricating or manufacturing methods, although this preconception is vigorously opposed by a few leaders in the latter fields. Essentially, the problems confronting the press designer and the metallurgist involve versatility in size and shape of parts produced without loss of desirable microstructure, grain orientation, or other elements of inner structure which are responsible for strength, toughness and high endurance. Four of the five papers in the symposium dealt with this problem.

In a paper entitled "Requirements for Large, Light-Metal Forgings and Extrusions in the Aircraft Industries", G. W. Patten of Lockheed Aircraft Corp., Burbank, Calif., pointed out that large forgings and extrusions should be the most economical method of *(a)* meeting the space limitations set up in thin wings with high structural loads; *(b)* providing minimum weights by eliminating "bits and pieces"; *(c)* improving sealing for pressurization and fuel by eliminating sources of leakage; *(d)* improving aerodynamic smoothness; and *(e)* reducing the man-hours that are required to fabricate and assemble aircraft.

Large, Sound Ingots – Some of the problems introduced by the size factor have been attacked in the production of high-strength aluminum alloy structural members. Most of the work has been performed on the well-known aluminum alloys 14S, 24S and 75S. **T. L. Fritzlen**, chief metallurgist of Reynolds Metals Co., Richmond, Va., in "Metallurgy and Production of Suitable Aluminum Alloy Ingots for Large Forgings and Extrusions", pointed out that a 32-in. diameter ingot, from which could be extruded a 12-in. bar or shape for

Fig. 1 – Large Steel Ingot Already Partially Flattened Goes Into the Reheating Furnace at Homestead Works, U. S. Steel Corp., to Be Brought Back to Temperature of 2200° F. for Subsequent Working

Direct Chill Process for Aluminum

subsequent forging, would not produce as uniform a structure as rolled forging stock because of the nature of the extrusion process. He further pointed out that unless the stock is upset prior to making certain types of forgings, abnormalities in structure and grain size will result. Thus, some forgings require additional press time and cost if they are made of extruded instead of rolled stock.

Fritzlen went on to discuss the problems in the casting of ingots for the large press program. He described the "direct chill process" in detail, since this somewhat specialized method appears to be the most likely for casting large aluminum ingots of the strong alloys.* The direct chill process consists of pouring molten aluminum alloy from a nearby furnace at a controlled temperature into a short sleeve of required size, made of sheet metal. This "mold" is water cooled and temporarily closed at the bottom by a retractable platform.

As the aluminum alloy is poured into the mold it solidifies at the same rate, and the bottom of the mold is lowered, carrying down the solidified and solidifying portion of the ingot into or through water sprays. The rate of lowering the solidifying ingot matches the amount of molten metal poured into the mold. Rapid freezing prevents undesirable segregation.

The ingot must be as uniform as possible in chemical composition and fine in grain structure. Cracks, splits, porosity, and nonmetallic inclusions cannot be tolerated. Fritzlen warns that the quality of a poorly cast ingot cannot be improved by subsequent working, although the converse is true – a good ingot can be changed into a poor one by improper subsequent treatment.

Since the solidification range of 14S, 24S and 75S is from 230 to 290° F., these alloys are subject to inverse segregation – constituents richer in alloying elements freezing out in the exterior region of the ingot. This phenomenon is the topic of a considerable technical literature, and Fritzlen believes that inverse segregation is caused by shrinkage of the first alloy to solidify, causing the still molten alloy, richer in alloying elements, to be squeezed in the direction of the heat flow. Since the heat flows downward into the mushy, half-solidified core, but primarily to the outer skin of the ingot, the outer portion is infiltered with compounds high in alloying elements. Although it is less than that obtained by rapid casting into large molds – as is done normally in steel plants – the variation in chemical composition within a direct-chill ingot amounts to a few tenths of one per cent of copper. (Alloyed 14S and 24S ingots contain around 4.5% copper.)

The eutectic compositions are found on the ingot surface in the form of exudations. These undesirable, brittle structures may result from the shrinkage of the outer dimensions of the ingot during solidification, opening a space between the mold wall and ingot surface into which the liquid eutectic is forced by the hydrostatic pressure of the melt, or possibly by gas pressure. They are usually removed by machining prior to rolling.

The desirable structure in these cast ingots is a fine equiaxed grain, with a fine and well-distributed insoluble constituent. This type of structure is believed to produce excellent hot workability in all directions.

One of the main problems in the production of large cast ingots is the tendency to crack. Calculations of the induced stresses set up in the cast ingot indicate that they approach the ultimate strength of the hot metal. Investigators are not completely sure of the mechanisms involved; one theory is that cracking is primarily a function of the thermal properties of the particular alloys, and secondarily, perhaps, of hot shortness. However, there is not a great deal of difference in the physical properties of the three alloys. Ranged in order of susceptibility to cracking from least to greatest, 14S-O, 24S-O and 75S-O have coefficients of thermal expansion of 24.5, 24.7 and 26.0 $\times 10^{-6}$ respectively. Their respective freezing ranges (liquidus to solidus) are 1180 to 950° F., 1180 to 935° F., and 1180 to 890° F.

British students of hot shortness have correlated it with chemical composition, at least as far as annular rings of aluminum-copper-magnesium alloy are concerned. Their results check with German investigators on 63 different analyses in the same ternary system, chill-cast under identical conditions. Certain ranges of composition were found to be crack-sensi-

*Editor's Footnote: The original "hardened" aluminum used in German aircraft and Zeppelins during World War I could not be manufactured in the United States until methods were devised whereby the ingots of correct composition could be cast without undue segregation of the necessary chemical constituents. The "direct chill casting" of such ingots in large cross section was not commercialized by W. T. Ennor of Aluminum Co. of America until as late as 1935. The process is closely related to the continuous casting of brass slabs by Scovill Mfg. Co. described at length in *Metal Progress* for January 1950, and the continuous casting of steel billets at Babcock & Wilcox Co. noted briefly in "Critical Points" on p. 87.

tive. Experience in America indicates that even slight variations in chemistry may result in a cracked or split ingot.

Quality of Press Forgings – In their paper, "Large Forging Press Operations and Production Problems", G. W. Motherwell, J. R. Douslin, and A. L. Rustay of Wyman-Gordon Co., Worcester, Mass., offered the opinion that two phases of quality control of large forgings are only partially controllable by press techniques. These are the attainment and maintenance of adequate transverse mechanical properties, and the attainment and maintenance of satisfactory internal soundness. The authors illustrated this thesis by landing-gear forgings with unsatisfactory transverse mechanical properties in some areas. While the difficulties are not yet entirely avoided, acceptable forgings are now produced with the aid of a considerable amount of mechanical work prior to die forging, and by some improvement in the quality of the raw material. In such a forging, metal flow must be controlled so that material originally adjacent to the ingot center is not permitted to move into the flash, else flash-line defects will appear.

To illustrate design problems, the authors showed an airframe fitting where "unhealed porosity" had been troublesome. After studying the manner in which this part is stressed in flight, airplane manufacturers have liberalized inspection standards, to enable normal production. Since ultrasonic inspection standards for this part vary from area to area as service levels vary, the matter can be approached in at least two ways: *(a)* The optimum solution is sufficient improvement in forging stock; *(b)* an analysis of processing methods will improve the design of tools and processes so as to maintain and improve the characteristics of the forging stock which conforms to present specifications.

Characteristics and Production of Extrusions – In a paper entitled "Large Extrusion Press Operation and Production Problems", T. F. McCormick of Aluminum Co. of America defined his field of "large extrusion presses" as those with a rated capacity of 4000 tons or more. (Alcoa's largest is 14,000 tons.)

Although considerable effort has been made to design dies on a scientific basis, die making is still an art. No *rationale* exists as yet; all practical die design is still empirical, and this is particularly true for large and complicated shapes. Dies for many nonsymmetrical shapes may be tried and altered several times before a satisfactory extrusion is obtained. Such alterations are expensive, consume much press time and manpower, and waste ingot stock. Extrusions which taper from end to end have been proposed on several occasions; in Mr. McCormick's opinion the best method of producing tapered sections is to group a number of them in a symmetrical design around a central mandrel which is contoured to produce the desired taper, and which is withdrawn at a proper rate so that the extrusion has the required dimensions, end to end.

Discussing the alloy to be extruded, pressure available, extrusion ratio, temperature of ingot and cylinder, and permissible extrusion speed, the author stated that these are all interrelated variables. In direct extrusion, maximum pressure is required to start the operation; however, pressure then decreases progressively. This is related to the area of contact between the ingot surface and cylinder liner. Any increase in ingot length requires a corresponding increase in starting pressure. Length of ingot is usually less than four times the diameter.

Extrusion rate is directly proportional to the pressure applied. As the ratio of the cross-sectional area of the cylinder opening to the area of the extrusion – termed the extrusion ratio – becomes smaller, less pressure is necessary. The extrusion ratio varies from a usual minimum of 10 to over 100.

In extrusion practice, the author pointed out that an increase in ingot and cylinder temperatures decreases the pressure required for metal flow, but also reduces the possible extrusion speed. Where extrusion speeds are slow and critical, temperatures should be held at the lowest values compatible with maximum available pressure. Although extrusion is primarily a compressive process, tensile stresses do develop in the outer fibers of the extrusion – sometimes so great as to exceed the strength of the metal. Large die openings exaggerate the effect of the stress gradient caused by unequal flow, and the extrusion rate must therefore be low. The higher the temperature developed in the emerging extrusion, the lower the speed at which surface breaking will occur; hence the lower the permissible extrusion speed. In aluminum alloys with low alloy content, comparatively high extrusion speeds and temperatures are possible before surface rupture occurs. High-strength alloys, with substantial alloying constituent, develop broken surface at lower temperatures and speeds.

(Continued on p. 182)

Advertisement

ELECTROMET *Data Sheet*

A Digest of the Production, Properties, and Uses of Steels and Other Metals

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How VANADIUM improves engineering steels and helps conserve critical alloys

In these critical times when many alloying materials are scarce, you may be able to use vanadium to good advantage. Steels alloyed with vanadium meet most of the mechanical specifications for low-alloy engineering and structural steels. In fact, vanadium can often be used in engineering steels to replace at least part, if not all, of certain alloys now in critical supply.

The metallurgy of vanadium is well known. Small additions of vanadium—0.10 to 0.30 per cent—can be used effectively to give steel extra strength, toughness, and resistance to fatigue and wear. It improves engineering steels by increasing their yield strength without sacrificing ductility. The uniformly fine grain size of vanadium-bearing steels makes them tough and resistant to abrasion, fatigue, and impact.

Better Mechanical Properties

In the following table are typical analyses for carbon-vanadium and chromium-vanadium steels that are suitable for most applications where low-alloy, high-strength steels are required. The carbon-vanadium steel is compared with plain-carbon steel; and the chromium-vanadium steel, with chromium-molybdenum steel. Note the excellent properties of the vanadium-bearing steels.

Fig. 1 — Vanadium increases the strength, toughness, and wear resistance of engineering steels for many machine parts, such as this large crankshaft.

Improves Cast Iron

A small addition of vanadium, usually from 0.10 to 0.25 per cent, refines the grain of cast iron, and materially increases its strength and hardness. Moreover, vanadium may be used in cast iron to replace at least part, if not all, of certain alloys that are now in short supply.

Vanadium in Rimmed Steel

An addition of approximately 1 lb. of vanadium per ton of steel produces non-aging characteristics in a rimmed steel. These non-aging properties, together with improved deep-drawing characteristics and the good surface inherent in rimmed steels, make these steels of particular interest at the present time.

Grades of Ferrovanadium

ELECTROMET produces ferrovanadium containing 50 to 55 per cent vanadium for the production of vanadium-bearing steels and irons. The alloy is produced in three grades with maximum 0.20, 0.50, or 3.00 per cent carbon and maximum 1.50, 2.00, and 8.00 per cent silicon, respectively. Each grade is specially adapted to fill the different requirements of iron- and steel-making.

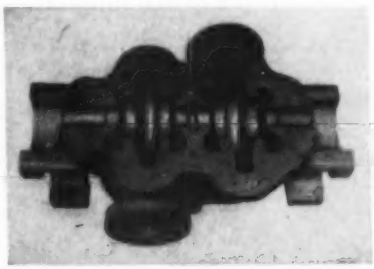


Fig. 2—Steel and iron castings treated with small additions of vanadium have high ductility and greater toughness and impact resistance.

Write for a copy of the booklet, "ELECTROMET Products and Service," which gives helpful information about the use of ferrovanadium and other alloying metals that ELECTROMET supplies. The booklet may be obtained from any ELECTROMET office: in Birmingham, Chicago, Cleveland, Detroit, Los Angeles, New York, Pittsburgh, or San Francisco. In Canada: Welland, Ontario.

Properties of Vanadium Steels Compared With Other Engineering Steels

Typical Analysis, %	Carbon Steel	Carbon-Vanadium Steel	Chromium-Molybdenum Steel	Chromium-Vanadium Steel
Vanadium	—	0.16	—	0.16
Carbon	0.50	0.49	0.50	0.50
Manganese	0.71	0.77	0.80	0.79
Silicon	0.19	0.15	0.30	0.31
Chromium	—	—	0.95	0.98
Molybdenum	—	—	0.20	—
Annealed and Furnace-Cooled				
Tensile Strength, psi	90,600	100,000	100,000	99,500
Yield Point, psi	48,900	66,000	50,000	64,100
Elongation in 2 in., %	23.3	25.0	23.0	28.4
Reduction of Area, %	37.8	49.1	45.0	59.0
Izod Impact, ft.-lb.	13.5	26.0	17.0	44.0
Quenched and Tempered				
Tensile Strength, psi	134,900	134,500	232,000	232,800
Yield Point, psi	110,800	128,000	214,500	224,200
Elongation in 2 in., %	18.3	18.3	10.0	10.4
Reduction of Area, %	54.1	56.6	39.0	43.1
Izod Impact, ft.-lb.	54.0	65.0	12.0	12.0

Correspondence

Micrographs With Polaroid Camera

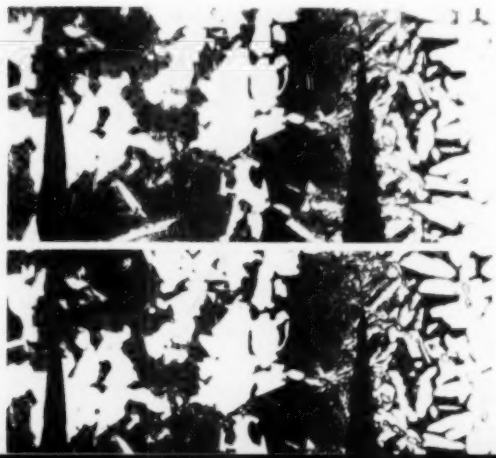
CLEVELAND

A Polaroid-Land camera has been adapted to a Bausch & Lomb ILS metallograph for use in the Metallurgical Development Section of the Lewis Laboratory of the National Advisory Committee for Aeronautics. This application has found immediate acceptance with gratifying results, and it is predicted will find wide usage in metallography in the near future.

Here, as in other laboratories, most micrographs are of a "data" nature, where one print is sufficient and where maximum quality is not required; this adaptation has added value in that it can handle the rush job, an ever-recurring nightmare in metallography, by reducing the time from exposure-to-print to 1 min.

A camera holder was made of wood to replace the 8 x 10-in. viewing glass at the rear of the camera. The Land camera back, which was purchased with an adaptor to fit a 4 x 5-in. Speed Graphic, is held in position by two sliding clamps allowing camera to be put in position, used, and removed without vibration. A viewing box was also made to fit the camera holder. This box holds a 4 x 5-in. ground glass in the same plane as the film in the Land camera. To use the camera, the camera holder with viewing box in position is placed into the ILS instrument. The image is composed and focused, the viewing box is replaced by the Polaroid camera and the exposure is made.

Fig. 1 – (Top) Polaroid Print, (Bottom) Conventional Print. 250 ×



The micrographs in Fig. 1 give a comparison of the Polaroid print (top) with a print made by our regular method (bottom). These prints were made at the same time, nothing being changed except the exposure which was 5½ sec. for Polaroid and 1½ sec. for Panchromatic type B film. The regular method print does show better tone quality and slightly better contrast. However, for many uses the difference in print quality does not justify the additional processing time and effort required by the conventional method. The latitude for exposure for Polaroid is not as wide as in regular film and, for best results, exposures should be correct to within about 10%.

H. ROBERT BEAR
Metallurgist
Lewis Flight Propulsion Laboratory

Fused Layers Formed by Tungsten Carbide Burs

ESKILSTUNA, SWEDEN

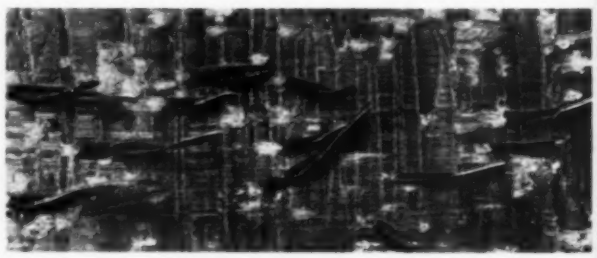


Fig. 2 – Surface of Metal Worked by Rotary Bur. Light Marks Are Fused Areas. 7.5 ×

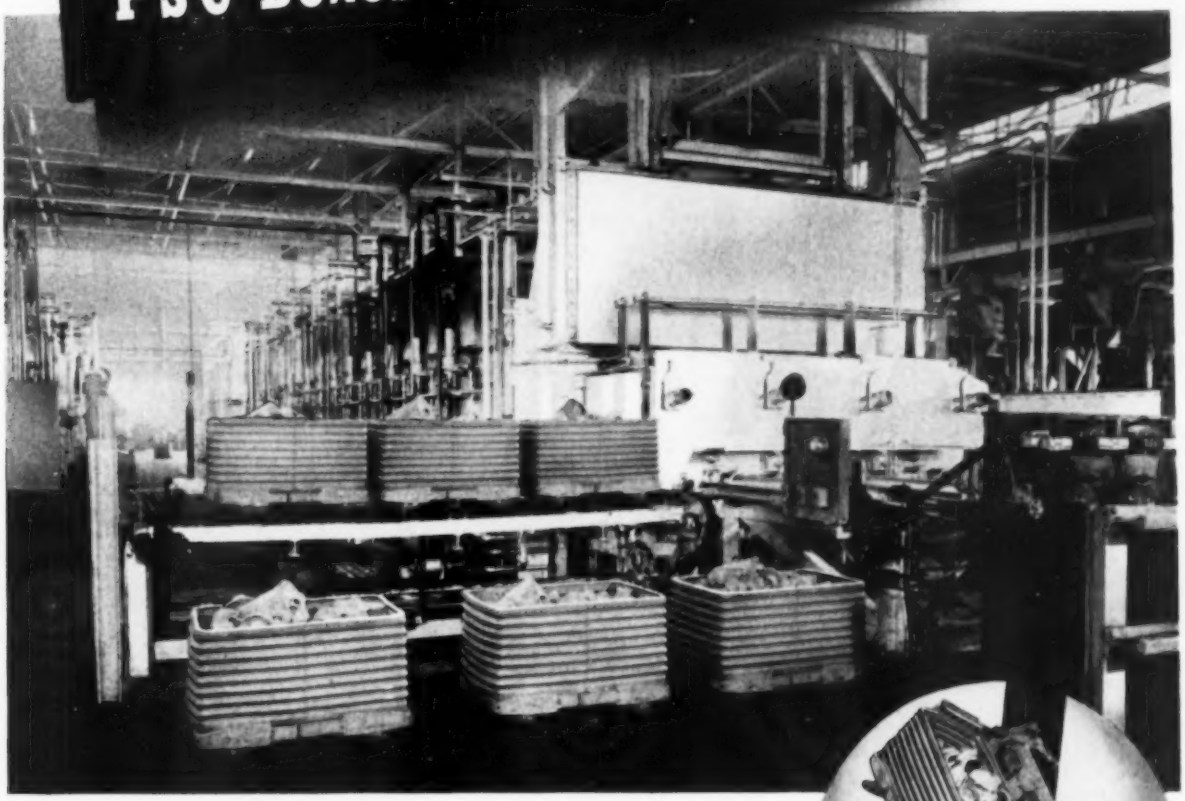
Following the appearance of the abstract "Wear on Cemented Carbide Tools" on page 186 in *Metal Progress* for May 1952, our laboratory investigated the working of metals with rotary burs made of tungsten carbide.

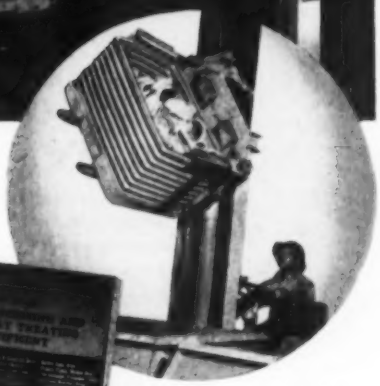
According to this article, evidence has been obtained that, during friction at high speeds, a fused alloy can be formed between tungsten carbide tools and steel. The fused layer is supposed to be very thin, only a small number of atoms in thickness, and the thickness depends on the cutting speed, the higher the cutting speed, the thicker the fused layer.

While working a toolsteel of quality D 65, a high alloy steel with about 2.10% C and 12% Cr, it was found that one end of the chips which sometimes remain on the surface that has been worked was stuck to the workpiece

(Continued on p. 118)

'Albion Malleable Iron' Chooses PSC Boxes for Huge Furnace





PSC Light-Weight Boxes Speed 800-lb. Loads for 120-ft. Long "Surface" Furnace

The above annealing furnace of Albion Malleable Iron Co., Albion, Mich., is one of the longest ever built by Surface Combustion Corp. It's 120 ft. long, and 11½ ft. wide inside. To effect ready flow of work to and from the great furnace, PSC "light weight" boxes were adopted and then designed for use with both roller trays and lift trucks, as pictured. As pioneers of light-weight, sheet alloy, heat-treating containers, we make available to you a wealth of production know-how. PSC furnishes equipment in any size and for any product. Send blue prints or write as to your needs.

Send for Heat-Treating Catalog 52

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Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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Fused Layers Formed by Tungsten Carbide Burs

(Continued from p. 116)

(see Fig. 2). The cutting speed was between 4900 and 6500 ft. per min., which may be considered abnormally high for most of the tungsten carbide tools; however, this high speed may sometimes occur with tungsten carbide burs.

Binocular-microscope examination showed that one end of the chips looked as though it were welded to the workpiece, and these "welds" appear as light spots on the surface that has been worked. All of the light spots indicate that the material had been molten or so near the melting point that the chips have sintered to the workpiece.

The chips, after having been torn loose from the steel, may have followed the file around once, thereby happening to hit between the steel surface and the edge of the tooth, already then somewhat torn off, in such a way that the heat generated by the friction between file and work has become sufficient to melt the material. There are plenty of light spots to which no chips are stuck, and these spots also show a surface structure which indicates that the material had been molten.

The tests made show that the author of the article is right in surmising that a fused layer can be formed between the cutting edge and the workpiece.

BERTIL ANDERSSON
Laboratory Director
C. O. Oberg & Co.

Answers to Questions on Dilastrain* Method

TROY, N. Y.

In his "Comments on Dilastrain Method" in the November 1952 issue of *Metal Progress*, Nicholas Grossman presented several questions which we wish to answer for those interested in this method.

1. How can the change in thermal expansion "be applied to a combined stress analysis?" Regardless of the type of stress used, there is one value at which the physical properties change abruptly, this being the endurance limit. This is not theoretical but is amply substantiated by experimental data. Of course, it is not possible to isolate the effect of each type of stress in a stress combination.

2. Can "the α-S curve be extended to stress levels other than the fatigue limit?" From the limited experimental work done to date it is not possible to do more than determine this value. However, the possibility of extension to other stress levels cannot be ruled out at this time.

3. "Which sets of data are more precise, the α-S curve or the S-N curve?" Other factors remaining constant, the precision of the S-N curve depends upon the number of specimens tested. The α-S curve, on the other hand, is independent of many variables which contribute to scatter and it is therefore much more precise. In reality, these curves cannot be compared because only one point is common to both of them.

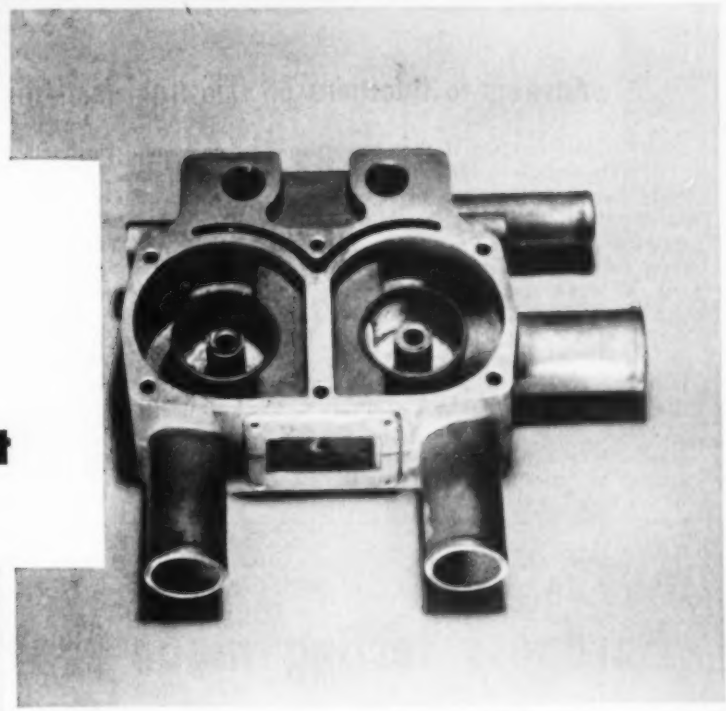
4. "Which quantitative determination requires greater skill, α or N?" No skill is required to read N from a counter, but technical skill is required for the preparation and analysis of data used for the S-N curve. Similarly, a careful laboratory assistant can be trained within a few days to operate competently a Dilastrain analyzer, but some technical knowledge is helpful in the interpretation of results.

(Continued on p. 120)

*Trade Mark

PRODUCT:
De-icer pump casting
MATERIAL:
Aluminum alloy
EQUIPMENT:
140 kv x-ray machine

What's the right X-ray film?



KODAK INDUSTRIAL X-RAY FILM, TYPE A

IN ADDITION to the vital importance of this unit to the safety of aircraft and airmen, close machining was called for. So to be sure that no porosity existed to cause weakness or waste valuable machining time, all castings were radiographed.

For these radiographs, the radiographer used 90 kv, 60-sec. exposure at 40-in. tube distance—no lead screens—and Kodak Industrial X-ray Film, Type A.

This film is the first choice for examination of light alloys using short exposures at low voltages. It also has high contrast with fine graininess and speed enough to take full advantage of high kilovoltage equipment in radiographing thick or dense materials.

A RIGHT FILM FOR EVERY PROBLEM

Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

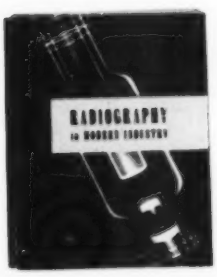
Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage and for examining heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity, with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage, without use of calcium tungstate screens.

Radiography . . . another important function of photography



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, $3.

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Kodak
TRADE-MARK

Answers to Questions on Dilastrain Method

(Continued from p. 118)

5. "The surface condition is claimed to be less important than in conventional testing. This appears somewhat incongruous. . . ." Assuming that there are no surface imperfections and that all eight specimens in a Dilastrain test series have been carefully machined, it can be claimed that surface condition is less important. This is true because not more than 100,000 stress cycles are used ordinarily in the Dilastrain method and this is an insignificant percentage of the total number of cycles at or even near the endurance limit. Nevertheless, we believe that this method has possibilities for the evaluation of surface condition if all specimens in a series have similar surfaces and reversed bending is used in the investigation.

6. "To relate fatigue limits with yield values is very questionable." We are in complete agreement with Grossman on this point and wish to emphasize that no such implication was intended in our article published in the February 1952 *Metal Progress*. We specifically gave the ratio of *endurance limit* in reversed bending to the *endurance limit* in torsion and no statement was made extending this ratio to all materials.

7. The final question relates to the introduction of new definitions; only *two* were suggested, the "true yield point" and "true endurance limit". Since they do not conform with corresponding terms as currently used, it was anticipated that they would be challenged. This is all to the good. Many of our present definitions are modifications of older definitions. We do not believe that anything in science and engineering is inviolate in the sense that nothing new can be added.

"True yield point" is the stress at which nonferrous as well as ferrous materials show a definite and abrupt change in physical properties when subjected to static loads. It is not an arbitrary point based upon some percentage of offset. While the commercial usefulness of "yield point" at some specified percentage of offset is not questioned, it cannot be said to have a precise structural meaning.

"True endurance limit" has a parallel connotation when the material is subjected to repeated load cycles. It, too, has definite structural meaning.

We are grateful for Grossman's commendation and are pleased to answer his questions. There are many questions which others have presented to us for which no answers are yet available. We are convinced that many fundamental fatigue problems may find a solution by the application of the Dilastrain method. Extensive research which should be undertaken in this field must inevitably expand our understanding of the mechanics of the solid state.

JOSEPH L. ROSENHOLTZ
DUDLEY T. SMITH
Rensselaer Polytechnic Institute

German Research

SANDVIKEN, SWEDEN

Recently I was fortunate enough to visit the Max Planck Institute in Düsseldorf, West Germany, and saw many things which may be of current interest to other members of the American Society for Metals. It is hard for me to restrain my enthusiasm for the work done there since its reopening about three years ago under the direction of F. Wever.

Among other things, they showed me electron photomicrographs at 120,000 diameters magnification, as sharp and crisp as any taken at moderate magnification with an ordinary microscope. I had never hoped to see such a micro where 1μ is enlarged to 12 cm. or nearly 5 in.

(Continued on p. 122)

telling the story of 'dag' dispersions

Lubrication Troubles Above 500°F? Try This!

Use a **'dag'** dispersion. At high temperatures it has conventional lubricating agents beat a mile. Why? Because at ordinary metalworking temperatures it doesn't burn off, flake, or gum up. It successfully battles oxidation at every temperature up to 750°F.

'dag' dispersions of graphite form microscopically thin, *dry lubricating films* which fight friction beyond the burning-points of most oils. These dry films are unaffected by heat up to 750°F. . . . under some conditions up to 3000°F.

For more details on metalworking applications write for Bulletin No. 426-10C.

* * *

Dispersions of molybdenum disulfide are available in various carriers. We are also equipped to do custom dispersing of solids in a wide variety of vehicles.

dag DISPERSIONS

Acheson Colloids Company, Port Huron, Mich.
. . . also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND
Units of Acheson Industries, Inc

try resin-bonded dry graphite films for permanent lubrication

German Research

(Continued from p. 120)

At the end of the war there were about 45 electron microscopes in use throughout all Germany and some 15 more under construction. Of these, only ten could be saved for research in West Germany, the rest being taken by one or the other of the occupying forces. The microscope now in use at the Institute is one of the new postwar models manufactured by Siemens.

Of special interest to me were the studies of the structural changes in steel upon continuous cooling by an ingenious method which simultaneously records dimensional changes, temperatures and time. In parallel with these studies, they have obtained transformation diagrams for steels upon isothermal holding.

They have also developed greatly improved methods for the separation of oxides and carbides from solid steel. Through chemical, spectrographic, X-ray crystallographic and electron microscope analysis of electrolytic residues, they have been able to determine the relationships between the time and temperature of transformation and the composition and structure of the carbides formed, and the changes occurring during the reheating.

This research work has clarified the nature of various transformations and has confirmed Hultgren's theories concerning the occurrence of para and meta equilibria with different distributions of alloy constituents between ferrite and carbides. They have confirmed that bainite formation is associated with diffusion of carbon in gamma and not in alpha iron.

Among the many other interesting things which I saw were methods of measuring the pressure on rolls during rolling, a new type of mill for cold rolling, and two different methods of determining the internal contours of drawing dies.

CARL A. LIEDHOLM
Metallurgist
Sandvikens Jernverks Aktiebolag

Correction to Data Sheet on Copper and Brasses

The composition for free-cutting brass given in the data sheet, "Standard Commercial Wrought Copper and Brasses, Nonleaded and Leaded" (*Metal Progress*, December 1952), should have read 3.0% Pb and 35.5% Zn, instead of 0.6% Pb and 39.4% Zn. Copper content is 61.5%.

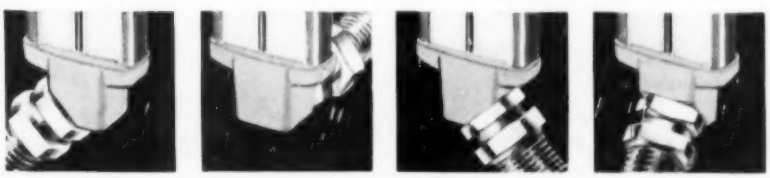
Bronze Extrusion makes a stronger sales case for this industrial glass thermometer

The case for this "American" Industrial Glass Thermometer made by Manning, Maxwell & Moore, Incorporated, Stratford, Conn., used to be a steel stamping. Now it's made of ANACONDA Extruded Bronze.

Why the change? Because this extruded bronze shape makes a far stronger and more rigid case; it's easier to produce; it simplifies assembly—and adds additional quality to an already high-quality product. So accurate are these bronze extrusions that neither straightening nor machining is needed for assembly. And assembly time itself is cut.

For the base, an ANACONDA Brass Die Pressed Forging is joined to the case by brazing to provide greater joint strength. By machining the appropriate face of a single-style base forging, a stem connection can be provided at any angle.

ANACONDA Brass and Bronze have long been making a stronger "case" for products—by simplifying production; by the higher quality that is always associated with products made of brass or bronze; by increasing sales appeal. We urge you to consider the advantages of these metals for your manufacturing processes and your products. For information, write to The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.



Base forging can be machined to provide stem connection at any angle and direction.

Extruded case and forged base for this 9-in. "American" Thermometer are joined in perfect alignment by brazing. No machining or straightening is required.

ANACONDA® —the name to remember in COPPER—BRASS—BRONZE

Cold Die Quenching

TOTTENHAM, VICTORIA
AUSTRALIA

Recently we had occasion to make use of cold die quenching for the combined hardening and straightening of thin sections of an air hardening steel. A. F. Gallistel ("Cold Die Quenching", *Steel*, March 4, 1946) reported the successful use of this technique for hardening such articles as washers and keeping them flat to ±0.005 in. The occurrence of a number of cracks in the hardened parts led to a study of the die quenching technique, and subsequent measurements showed that certain areas were cooling ten times as fast as other areas. The sections cooling first showed cracking similar to the hardening cracks that are commonly found in an oil hardening steel.

Since Gallistel reported that this technique can be used to harden a carbon steel to a considerable depth (Rockwell C-60 at a depth of 0.20 in.), cold die quenching should actually be classed as a water or brine quench in those areas in close contact with the dies.

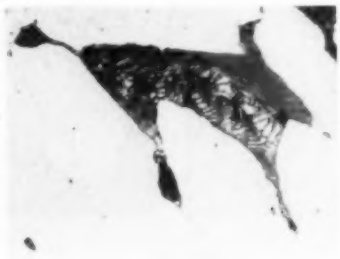
Although defeating the purpose of a quench for water hardening steels, asbestos pads or heated dies provide a simple and efficient quenching arrangement for hardening and straightening these steels.

ROBERT L. KAMM
Metallurgical Engineer
Research Department
Wiltshire File Co.

A Pearlite Bull in a Ferrite Field

CHATTANOOGA, TENN.

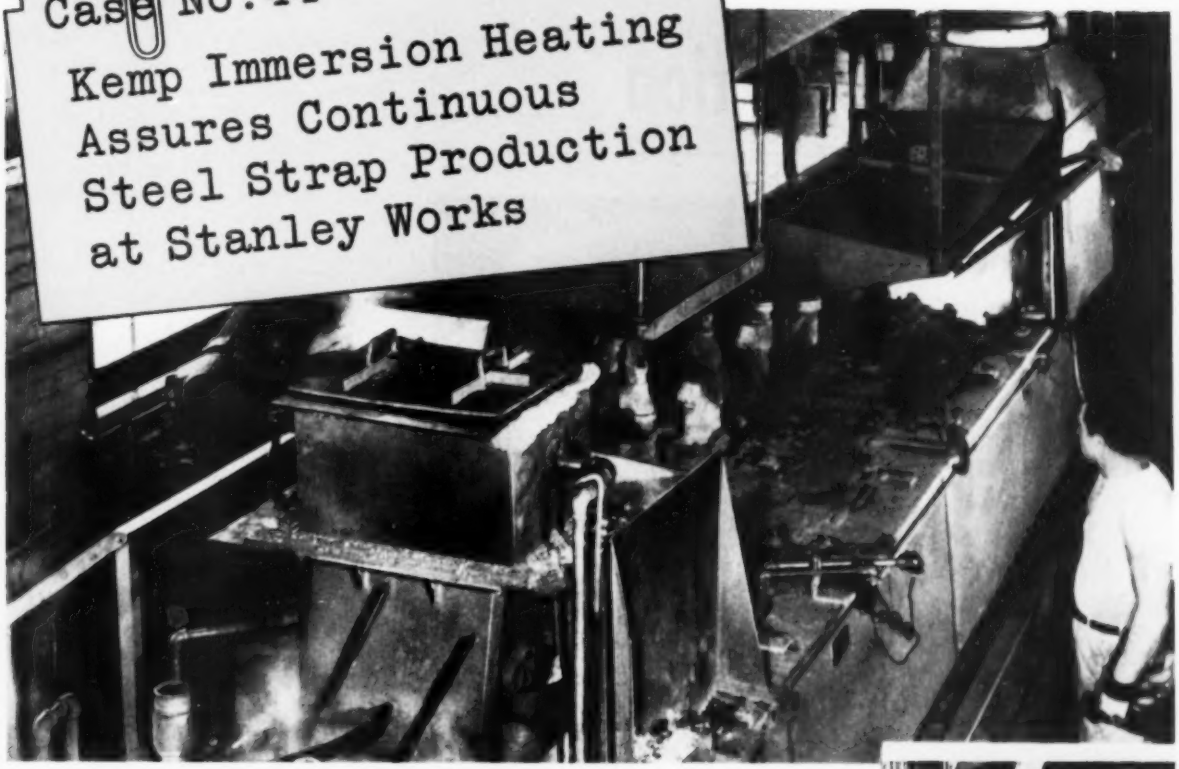
Here is evidence of what many outside the metallurgical field have long suspected; that is, there is "still a lot of bull in metallurgy". This unusual animal was found in a low-carbon steel, and is shown at 600 × after a nital etch.



L. N. WALL
Metallurgist
Combustion Engineering-Superheater, Inc.

Case No. 44

Kemp Immersion Heating Assures Continuous Steel Strap Production at Stanley Works



How Stanley doubled steel strap capacity overnight . . . slashed fuel costs, too

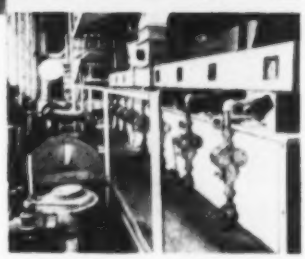
Today this bustling division of the famous Stanley Works at New Britain, Conn., turns out steel strapping on a 24 hour basis. Starting with raw, high carbon steel on giant spools, strap is semi-annealed, finished, coated and rewound again for shipping in one *continuous* process. New rolls of raw steel are simply spot-welded to the ends of rolls to eliminate any interruption.

Kemp Eliminates Bottleneck

From an output limited by the capacity of a gas underfired pot, production was doubled on the installation of a 32 ton Kemp Immersion Melting Pot. In addition, Kemp's *greater* heating surface, *faster* heat recovery, *lower* dross formation and *accurate* temperature controls meant real savings in fuel costs. In the words of Mr. Harold Heckman, plant foreman, "Through quicker heating of this pot, we are able to maintain production schedules." And unlike underfired pots, Kemp units eliminate open flame hazards and excessive room temperatures.

Let Kemp Help with Your Problems

If you're dissatisfied with your present heating or melting equipment, consult Kemp first before you make any changes. Let Kemp Engineers show you how they can solve your tempering, annealing, descaling or coating problems quickly and easily. Then just like the Stanley Works, you'll be *time* and *money* ahead.

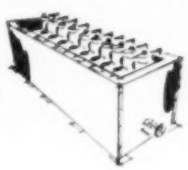


Rear view of Kemp Pot at Stanley Works shows gas feed lines, fire checks, and the Kemp Carburetor (left). Part of every Kemp installation, this carburetor assures complete combustion . . . without waste . . . without tinkering. Just set it, and forget it.

For more complete facts, ask for Bulletin IE-11. Write: C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.

KEMP OF BALTIMORE

IMMERSION MELTING POTS



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Personal Mention

Umbert F. Corsini

Wade B. Houk

UMBERT F. CORSINI has been appointed general superintendent of the Steel & Wire Works of the American Steel & Wire Div., U. S. Steel Corp., in Donora, Pa., it was announced recently. Previously general superintendent of American Steel & Wire's South Works in Worcester, Mass., Mr. Corsini began his steel career as a machinist in the Worcester plant in 1933. After several promotions he moved into the operations end of steelmaking by becoming a student apprentice in the openhearth and rolling mill in 1935. Three years later he was made assistant general foreman of the rolling mill, and in 1941 became assistant superintendent of the open hearth department. Two years later he was promoted to assistant division superintendent of the steel works, then division superintendent in 1945, and general superintendent in 1950. Mr. Corsini, who was born in Plymouth, Mass., in 1911, holds a B.S. degree from Worcester Polytechnic Institute. About three years ago he was a member of a mission to Pakistan, India, where with U. S. Steel Export Co. and other executives he surveyed the needs of that country in connection with its industrialization under the Government's Point IV program. The mission was organized at the invitation of the Pakistan government.

Succeeding Mr. Corsini as general superintendent of the American Steel & Wire Division's South Works in Worcester, Mass., is WADE B. HOUK. Mr. Houk has been division superintendent of South Works' wire mills. A native of New Brighton, Pa., he was born there in 1912, completed his early education there and graduated with a B.S. degree in metallurgy from Pennsylvania State College in 1933. His first employment with American Steel & Wire was in 1936 in the metallurgical laboratory of the Division's old North Works in Worcester, Mass. After several promotions in the metallurgical department at Worcester's North and South Works, he became assistant division superintendent of South Works' wire division in May of 1945. Two months later he was named department superintendent in cold roll, and in 1947 was made division superintendent of the wire mill, a position he has held up to his latest promotion.

William A. Reich has been appointed manager of advance development engineering at the Carboloy Dept., General Electric Co., Detroit. For the past seven years he has been engineer in charge of the metallurgy section of General Electric's Turbine Division Laboratory in Schenectady, N. Y.

Harold E. Cleaves has retired as chief of the chemical metallurgy section at the National Bureau of Standards after 26 years of service. He entered the chemistry division in 1912 and left the Bureau in 1916, returning as a member of the staff of the metallurgy division in 1930. He was appointed chief of the chemical metallurgy section in 1946. A graduate of the University of Washington, Mr. Cleaves took his B.S. degree in chemical engineering in 1912. In recognition of his outstanding contributions in the investigation of pure iron at the Bureau, he received the Department of Commerce Meritorious Award in 1949. In recent years he has contributed significantly in classified work for the Atomic Energy Commission, and was given a citation by the War Department for his work on the Manhattan project. He has written numerous technical papers and is co-author of the book "The Metal — Iron", one of the Alloys of Iron monograph series published by the Engineering Foundation. He holds several patents for methods of treatment of ores. Mr. Cleaves is a member of many technical societies, and in 1951 was a conferee at the First World Metallurgical Congress, sponsored by the .

James W. O'Brien has been transferred from the research laboratory of Federal-Mogul Corp., Ann Arbor, Mich., to their plant at Greenville, Mich., where he is now assistant plant metallurgist.

Robert J. Denn, air force reserve officer on active duty, is at present assigned to Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio, where he is a development project engineer in the power plant unit of the engineering branch. Lt. Denn returned last fall from Korea where he was an F-84 Thunderjet pilot.

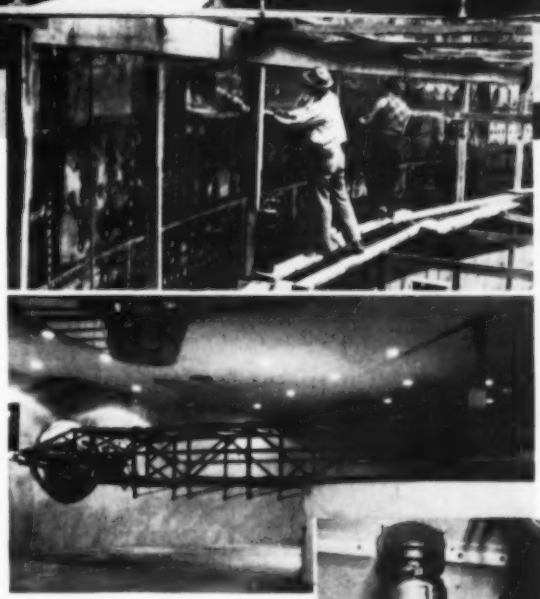
E. W. Ruhe was recently appointed mechanical projects engineer for the metals division, Olin Industries, Inc., at East Alton, Ill. Prior to joining Olin Industries in January 1950, as machine design engineer, he was employed by the Morgan Engineering Co., Alliance, Ohio.

COPPER

can insulate as well as conduct!

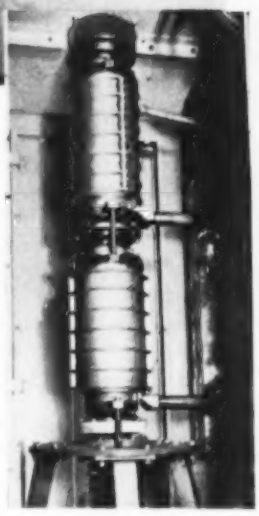
Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pa.

The fact that copper has the highest electrical conductivity of all the commercial metals not only makes it the preferred metal for carrying current, but also results in its adoption for shielding. Electrical and electro-magnetic disturbances, currents and fields cannot pass through a grounded shield of copper sheet. In this sense, then, copper becomes an insulator. It is widely used for this purpose in laboratories, to assure the accuracy of delicate instruments. A recent spectacular example of such an application is in the Aviation Medical Acceleration Laboratory of the U. S. Naval Air Development Center, Johnsville, Pa. The purpose of the Centrifuge is to test the tolerances of men and animals to the types of acceleration and deceleration produced in military aircraft and to study the physiological conditions which set limits to such tolerances. Recording instruments attached to the subjects are extremely sensitive, but thorough shielding by sheet copper makes it possible to record brain waves without amplification . . . Revere will gladly collaborate with you on scientific and industrial applications of copper and its alloys, and aluminum alloys. See the nearest Revere Sales Office.



Revere Sheet Copper shielding being installed on wall of the Centrifuge chamber by The Howard P. Foley Co., Electrical Contractor, 1630 Pine St., Philadelphia 3, Pa.

A view of the human centrifuge itself. This can produce positive, negative or transverse "G", through accelerations up to 40 times the force of gravity. A great many records are made of each test, including X-ray motion pictures. The subject is observed continually by television.



Upper slip-ring stack—physiological, signal and power. Here copper serves as a conductor.

Official Photographs from U. S. Navy

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Personals

N. E. Hamilton has accepted a position in metallurgical engineering development with Avesta Jernverks Aktiebolag, Sweden. He was formerly project manager with National Research Corp., Cambridge, Mass.

Thomas R. Evans is now working in production development of shell molding process at the Central Foundry (Danville, Ill.) of General Motors Corp.

Leonard J. Gagola, who graduated from the University of Illinois in February with a B.S. in metallurgical engineering, is with Foote Bros. Gear Co., Chicago.

Nelson W. Dempsey has been promoted to the position of manager of operations of the Chicago District of American Steel & Wire.

Walter L. Hodapp has been appointed supervisor of the metallurgical laboratory, Sanderson-Halcomb Works, Crucible Steel Co. of America, Syracuse, N. Y.

W. R. Mayberry is now a metallurgist with Solar Aircraft Co., Des Moines, Iowa.

Charles J. Meinhart, recently discharged from the U. S. Navy, is an instructor in the welding engineering department of California State Polytechnic College, San Luis Obispo, Calif.

Ralph N. Fitzpatrick has been appointed district manager of the Cleveland office of Electro Metallurgical Co., Div. of Union Carbide and Carbon Corp. For the past six years he has been in the Cleveland office as a salesman.

Leonard R. Kohan is now a laboratory control technician in the heat treating section, Ford Motor Co., Aircraft Engine Div. He recently graduated from Illinois Institute of Technology.

Gordon F. Hubbert, formerly with the Chicago sales office of Wheelco Instruments Co., has been appointed district manager for the Wheelco Instruments Div., Barber-Colman Co. in Detroit.

Bruce W. Glenn has been appointed vice-president in charge of sales at L. R. Kerns Co., Chicago.

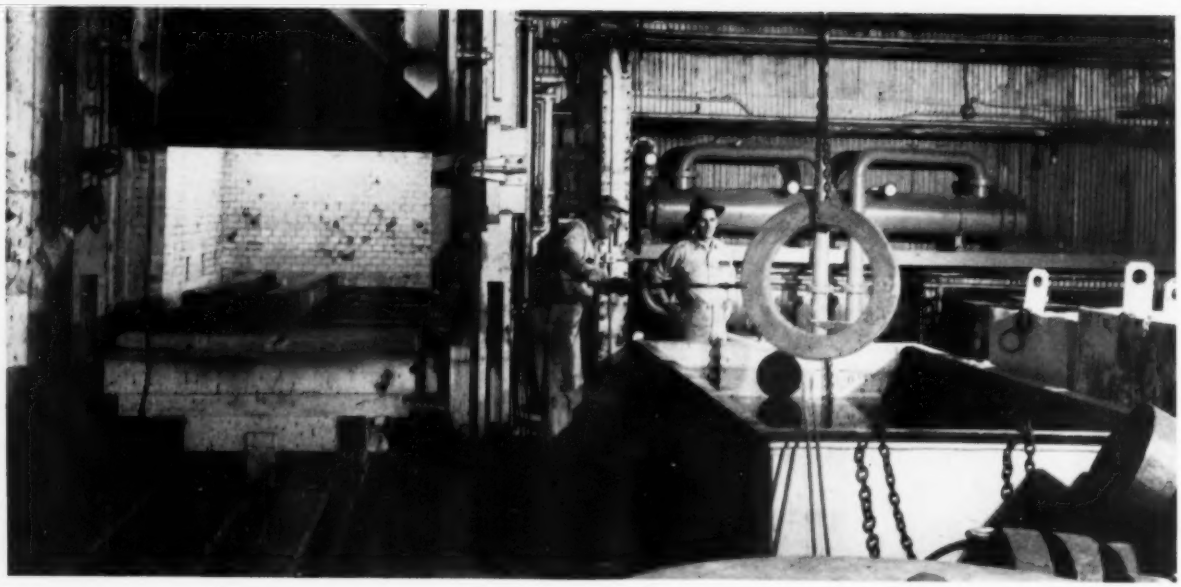
Every tiny bit of JESSOP steel is bigger than its job

There's a very simple reason for Jessop's fine reputation as a specialty steel maker. Jessop not only controls its formulae and processes with infinite care, it traditionally strives to produce better steel of each type than the end-use necessitates. Take, for example, the high-speed tool bits shown here. They cut harder materials faster and deeper than their basic analysis indicates, thus providing longer life and greater durability on normal jobs. Behind this tradition for extra quality is the keen desire for more business on the part of the Jessop producing and selling team. Every single Jessop man wants more satisfied customers. He wants them to be so enthusiastic they will forget there is anyone else in the world making special steels. Some customers already have.

HIGH SPEED STEELS · HIGH SPEED BITS · PRECISION GROUND FLAT STOCK · HIGH SPEED AND ALLOY SAW STEELS · HOT WORK DIE STEELS · COLD WORK DIE STEELS · CARBON AND ALLOY STEELS · GROUND AND TEMPERED PRODUCTS · STAINLESS AND HEAT RESISTING STEELS · STAINLESS-CLAD STEELS · CAST-TO-SHAPE STEELS · COMPOSITE TOOL STEELS · ARMOR PLATE

JESSOP

STEEL COMPANY · WASHINGTON, PA.

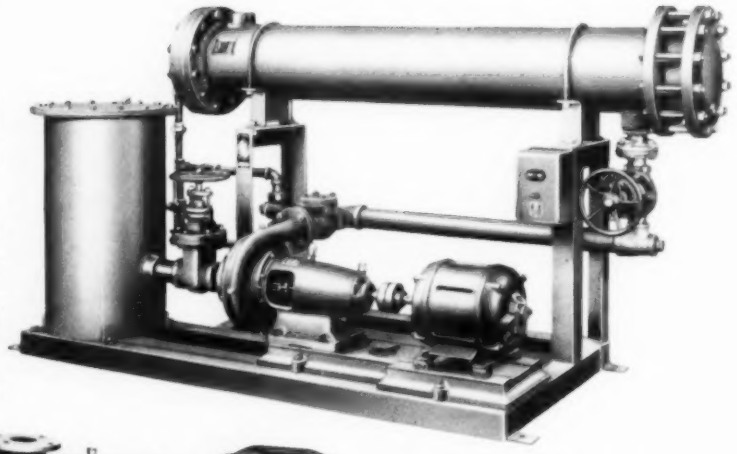


Control your Quenching FOR FEWER REJECTS

When you install a B & G *Hydro-Flo* Oil Quenching System you eliminate the warping and quality variations caused by uncontrolled quenching of heat-treated metal.

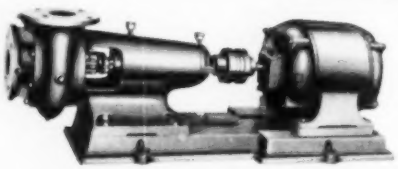
Oil is circulated at high velocity and with strong turbulence through the quench tank — then cooled and pumped back again. The oil in the quench bath is kept constantly at whatever temperature is desired. Since every batch is quenched under *identical conditions*, every batch is *identical in quality*.

Remember that the B & G engineering staff is always ready to help with your quenching problems.



Complete system or build your own

B & G Oil Cooling Systems can be purchased as completely self-contained units, or as individual parts to be assembled on the job. Heat exchangers and pumps are available in a complete range of sizes and capacities . . . quench tanks in either standard models or designed to your specifications.



B & G Self-Contained Oil Cooler

Pre-engineered and assembled at the factory — ready for connection to the quench tank and water lines. Send for combined Catalog and Selection Manual.

*Hydro-Flo** OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. CW-16, Morton Grove, Ill.

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto

*Reg. U. S. Pat. Off.

Latest facts about INCOLOY

Newest member of the Inco family

Incoloy® was developed as a companion to Inconel®, long considered one of industry's most durable high temperature metals.

The latest test results now definitely establish the importance of Incoloy as a new high temperature material. (See tables.) In fact, its most useful mechanical properties are comparable to those of Inconel at temperatures up to 1800°F.

Both metals offer good resistance to oxidation. But Incoloy, having a lower nickel content, is likely to provide greater resistance to sulfur attack.

In structure, Incoloy is stably austenitic, and shows no tendency to become embrittled by precipitation of sigma or carbidic phases after prolonged exposure to intermediate temperatures.

Note also, in the tables, the important preliminary creep and rupture data which have been developed on Incoloy.

Like Inconel, the new alloy is readily workable, both hot and cold. Its rate of work hardening is practically the same as that of Inconel. And Incoloy can be welded by commonly-used methods.

All of the usual mill forms are produced — billets, rounds, flats, hexagons, sheet and strip, rods, tubing and wire. Consult your distributor of Inco Nickel Alloys for the latest information on availability from warehouse and mill. And remember — it usually helps to anticipate your requirements well in advance.

Remember, too, that you can always call on Inco's High Temperature Engineering Service for assistance in selecting the *right* metal for any high temperature application. All you need do is write and ask for a copy of the "High Temperature Worksheet." This is a simplified form especially designed to help you highlight the essential facts of your particular problem. The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

Incoloy
Preliminary Creep and Rupture Data
Condition: Course Grained-Annealed*

Creep

Temp. °F	Stress, psi, to Produce a Minimum Creep Rate of: .01% 1000 hrs.	.10% 1000 hrs.
1400	4400	5500
1600	2000	2900
1800	250	500
2000		200**

Rupture

Temp. °F	Stress, psi, to Produce Rupture in: 1000 hrs.	10,000 hrs.	100,000 hrs.
1400	8700	6000	(4200)
1600	3800	2200	(1300)
1800	1700	1100	(670)
2000	850	(540)	....

*2 hrs. 2050°F AC
**.07% 1000 hrs. (4000 hrs.)

INCOLOY INCOLOY INCOLOY INCOLOY INCOLOY INCOLOY INCOLOY INCOLOY

INCO TRADE MARK

Inco Nickel Alloys

Incoloy... *for Heat-Resisting Applications*

Personals

Harold W. Lownie, Jr., ⊜ has been appointed to a supervisory post in Battelle Institute's (Columbus, Ohio) process metallurgy laboratories and will supervise much of Battelle's research related to foundry practice and ore reduction. He replaces **C. T. Greenidge** ⊜, a veteran member of the Battelle staff, who has been appointed an assistant to the director to serve as a liaison officer between research and executive activities.

Carl E. Schmitz ⊜ was recently appointed vice-president in charge of sales for Crane Packing Co., Chicago, Ill. He has been in the engineering department of Crane Packing since 1942.

William Hagel ⊜ has been appointed a member of the board of directors of United Engineering and Foundry Co., Pittsburgh. Mr. Hagel is vice-president in charge of sales, a position to which he was elected in 1946. He has been with the company since 1917.

Harold D. Moss ⊜, formerly in the general sales office of Brace-Mueller-Huntley, Inc., at Syracuse, N. Y., has been transferred to district manager of sales for the Southern Tier, with headquarters at Binghamton, N. Y.

William O. Sweeney ⊜ has joined Arwood Precision Casting Corp., Brooklyn, N. Y., as assistant vice-president of sales. He was formerly sales and development manager of the Haynes Stellite Div., Union Carbide and Carbon Corp.

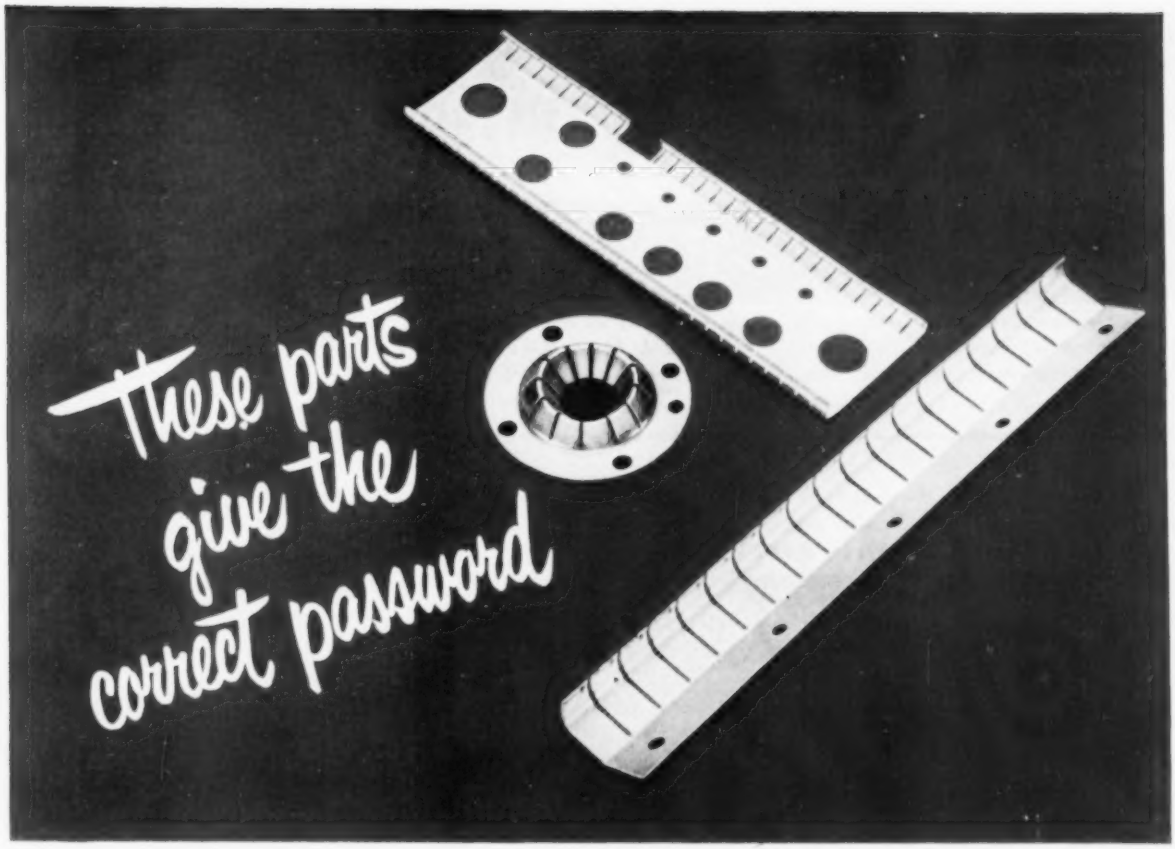
George Breyer ⊜, formerly chief metallurgist of Crucible Steel Co. of America's Midland (Pa.) Works, has been appointed metallurgical service engineer for the Detroit area. Mr. Breyer joined Crucible as a contact metallurgist in 1935, and was made assistant chief metallurgist of Midland Works in 1944 and chief metallurgist in 1945.

Eugene A. March ⊜ has been appointed chief metallurgist for Crucible Steel Co. of America's Sanderson-Halcomb Works located in Syracuse, N. Y. He moves into a job vacated by **David I. Dilworth, Jr.,** ⊜, who was recently appointed assistant director of metallurgy for the company. Previous to his new appointment, Mr. March was supervisor of metallurgical control at Sanderson-Halcomb. Before coming to Crucible, he was associated with Inland Steel Co., Indiana Harbor, Ind., where he served in the metallurgical laboratory and openhearth departments.

Donald M. Ashfal ⊜ has left Caterpillar Tractor Co., Peoria, Ill., to take a position with Armco Steel Corp. in their research laboratories in Middletown, Ohio.

Carl T. Hewitt ⊜ has retired from active service after 35 years with the Fafnir Bearing Co., New Britain, Conn. He was successively testing engineer, metallurgist, superintendent and chief metallurgist. Mr. Hewitt is past chairman of the Hartford Chapter ⊜ and has been an ⊜ member since the American Society for Steel Treating became the American Society for Metals.

Russell W. Burman ⊜, formerly with Chrysler Corp. and Caterpillar Tractor Co., is now project engineer with Climax Molybdenum Co. of Michigan.



Parts shown processed by H. Braun Tool & Instrument Co., Hawthorne, N.J.

THEY'RE MADE OF BERYLCO BERYLLIUM COPPER

If the IFF radar device used by aircraft should give the wrong signal, our own planes would be in danger of being shot down by antiaircraft and fighter interceptors. Small but vital beryllium copper parts prevent any such catastrophe.

To insure the correct signal, each finger in the circular part must have uniform tension and must line up perfectly. That's one reason why beryllium copper was chosen for this application. The required accuracy can be achieved only by fixture heat treating, and Berylco is the only material that can stand such severe forming and still retain its desirable spring properties.

Of course there are other reasons why this versatile alloy is used here. Its resistance to fatigue, corrosion and relaxation; its electrical conductivity; its indifference to temperature variations—all are important.

The ability of Berylco to offer the designer more than one desirable property has materially increased its application—for peacetime products as well as those used in defense. If you would like to include Berylco in your plans for the future, we invite you to share the knowledge of the world's largest producer of beryllium copper. Call or write any of the offices listed below for help or sample material.

THE MOST COMPLETE LISTING of available beryllium copper forms is contained in the Berylco *Product Directory*, just published. Send for your free copy today.

TOMORROW'S PRODUCTS ARE PLANNED TODAY—WITH BERYLCO BERYLLIUM COPPER

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Personals

Milton Male has been appointed manager of the building and construction industries section of U. S. Steel's commercial department, with headquarters in Pittsburgh. He has been director of housing research in the company's research and technology division since 1946. His new assignment will include responsibility for coordinating and assisting the technical activities of U. S. Steel's housing subsidiary, Gunnison Homes.

Robert A. Mayer has resigned his position at Wright-Patterson Air Force Base in Dayton, Ohio, to accept the position of buyer in the manufacturing division of W. "Pat" Crow, Inc., Fort Worth, Tex.

Robert W. Mason has joined Engineering Castings, Inc., Marshall, Mich., as superintendent and plant metallurgist. Prior to this change he was employed as foundry manager of National Farm Machinery Cooperative, Inc., Bellevue, Ohio.

Clark B. Carpenter, head of the department of metallurgy at Colorado School of Mines, has been appointed dean of the graduate school at the college. Prof. Carpenter, who has served on the Mines faculty since 1920, will continue his duties as head of the metallurgy department while also serving in his new position. As dean of the graduate school, he will be taking over a newly created position. He has been serving as chairman of the graduate committee with duties similar to that of dean. One of the best-known metallurgists in the country, Prof. Carpenter holds a B.Sc. degree in mining from the University of Kansas and a M.Sc. degree in mining from Massachusetts Institute of Technology. Prof. Carpenter spent two months this past spring in Great Britain as guest lecturer at the Royal School of Mines in London.

A. Den Adel has been transferred from Deere & Co., Moline, Ill., where he was metallurgist for the John Deere Wagner Works and the John Deere Planter Works, to the Des Moine Works as chief metallurgist.

S. R. Maloof is now associated with the power tube division of Raytheon Mfg. Co., Waltham, Mass., as senior engineer.

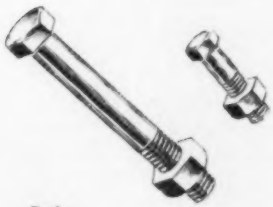
Otto Zmeskal, director of metallurgical engineering at Illinois Institute of Technology, has been elected employment service representative by the Chicago section of the American Institute of Mining and Metallurgical Engineers. Dr. Zmeskal has been a member-at-large of the Institute's executive committee for the last five years.

L. G. Lawrence is now supervisor of the laboratory, aircraft division, American Car and Foundry Co., St. Charles, Mo.

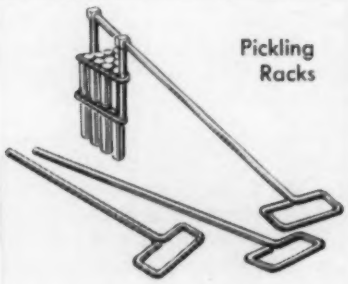
A. H. Barton resigned as assistant works metallurgist at International Harvester's Truck Engine Works, Indianapolis, Ind., to take a position as the metallurgist for Halfco Bearing Div., Aetna Steel Products Corp., Bridgeport, Conn.

Karl T. Aust, formerly with Kaiser Aluminum and Chemical Corp., Spokane, Wash., as research metallurgist, is now in the metallurgy division of Johns Hopkins University as a research associate.

Piston Rods



Bolts



Pickling Racks

Pump Shafts

HAYNES Alloy Bar Stock

Trade-Mark

FOR SEVERE SERVICE CONDITIONS

Four different HAYNES alloys are available in hot-rolled and forged bar stock for the fabrication of parts subjected to heat, corrosion, or oxidation. Each alloy has an unusual combination of properties to combat certain severe service conditions, as indicated by the chart below. Typical parts made from HAYNES alloy bar stock are piston rods, valve stems, pickling racks, pump shafts, bolts, needle valves and forgings such as automotive valves and turbine blades.

Round bars are available in diameters from $3\frac{1}{2}$ in. down to $\frac{1}{4}$ inch. Rounds larger than $3\frac{1}{2}$ in. in diameter can be obtained as hot forgings.

HAYNES alloy bars can be turned, ground, drilled, tapped, reamed, threaded, and welded.

For further information about HAYNES alloy bar stock, contact the nearest Haynes Stellite Company district office.

USE BAR STOCK OF	FOR RESISTANCE TO
HASTELLOY Alloy B (nickel-molybdenum-iron)	Hydrochloric acid, wet hydrogen chloride gas, sulphuric acid, phosphoric acid, organic acids, high temperatures.
HASTELLOY Alloy C (nickel-molybdenum-chromium-iron)	Nitric acid, free chlorine, acid salts, hydrochloric acid, sulphuric acid, phosphoric acid, organic acids, sulphurous acid, high temperatures.
MULTIMET Alloy (cobalt-chromium-nickel-iron)	Oxidation, high temperatures.
HAYNES Alloy No. 25 (cobalt-chromium-tungsten-nickel)	Oxidation, high temperatures, carburization, wet chlorine, nitric acid.

HAYNES

TRADE-MARK

alloys

"Haynes," "Hastelloy," and "Multimet" are trade-marks of Union Carbide and Carbon Corporation.

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

Personals

The following promotions have been announced at Bethlehem Steel Co., Bethlehem, Pa.:

John S. Marsh from engineer in the research department to assistant chief of research; **John K. Killmer** from metallurgical engineer to chief metallurgist; **C. Thompson Scott** from chief metallurgist at Sparrows Point plant to assistant general manager of the plant; **W. D. Poole** from assistant chief metallurgist at Sparrows Point plant to chief metallurgist of the plant; and **J. J. Link** from assistant metallurgical supervisor, tin mills division, Sparrows Point plant, to assistant chief metallurgist at the plant.

C. B. Post, chief metallurgist at Carpenter Steel Co., Reading, Pa., has been awarded the Bradley Stoughton plaque, which is awarded annually to the Lehigh Valley metallurgist who has accomplished the most outstanding and generally useful metallurgical work. This is the tenth annual award made by the Lehigh Valley Chapter, of which three have been awarded to Carpenter Steel metallurgical personnel.

Peter Patriarca, formerly materials engineer at Rome Air Development Center, has recently been appointed to the staff of Oak Ridge National Laboratory, an atomic energy installation operation by Carbide and Carbon Chemicals Co., a division of Union Carbide and Carbon Corp.

George S. Bond, chief engineer of the metals and ceramics division of P. R. Mallory & Co., Inc., Indianapolis, Ind., has been promoted to sales manager of the division. A chemical engineering graduate from Purdue University, Mr. Bond began work at Mallory as a junior research engineer 11 years ago.

Peter Budd Tursi has been named chief metallurgist at the Riverside Metal Co., Riverside, N. J. He has been associated with Riverside since 1936 when he began as a production worker. He was a testing engineer and later a metallurgist in the laboratory.

John W. Weaver has been named sales manager of the casting division of Waukesha Foundry Co., Waukesha, Wis. He has been associated with the company for the past 18 years in the sales department.

Survey of High-Chromium Alloys for Hard Facing*

SELECTION of suitable alloys for applications involving severe wear is a problem facing many engineers. Acceptability of high-chromium irons in which carbon and chromium combine to form a considerable volume of hard carbides of the Cr_7C_3 type is demonstrated by the fact that they have been used widely for both wear-resistant castings and for hard facing by gas or arc welding. Most common types contain 25 to 32% Cr and several per cent of C.

Matrix structures may be austenitic, pearlitic or martensitic, exerting considerable influence on wear resistance. The austenitic high-chromium iron, with 30% Cr and 5% C, usually is gas welded with a reducing flame that tends to increase carbon in the deposit. It produces welds with excellent resistance to erosion or low-stress scratching abrasion, but mediocre where there is high-stress grinding abrasion. The alloy shows little sensitivity to composition changes and most deposits will have hardness of Rockwell C-56 and erosion resistance 20 to 50 times that of mild steel.

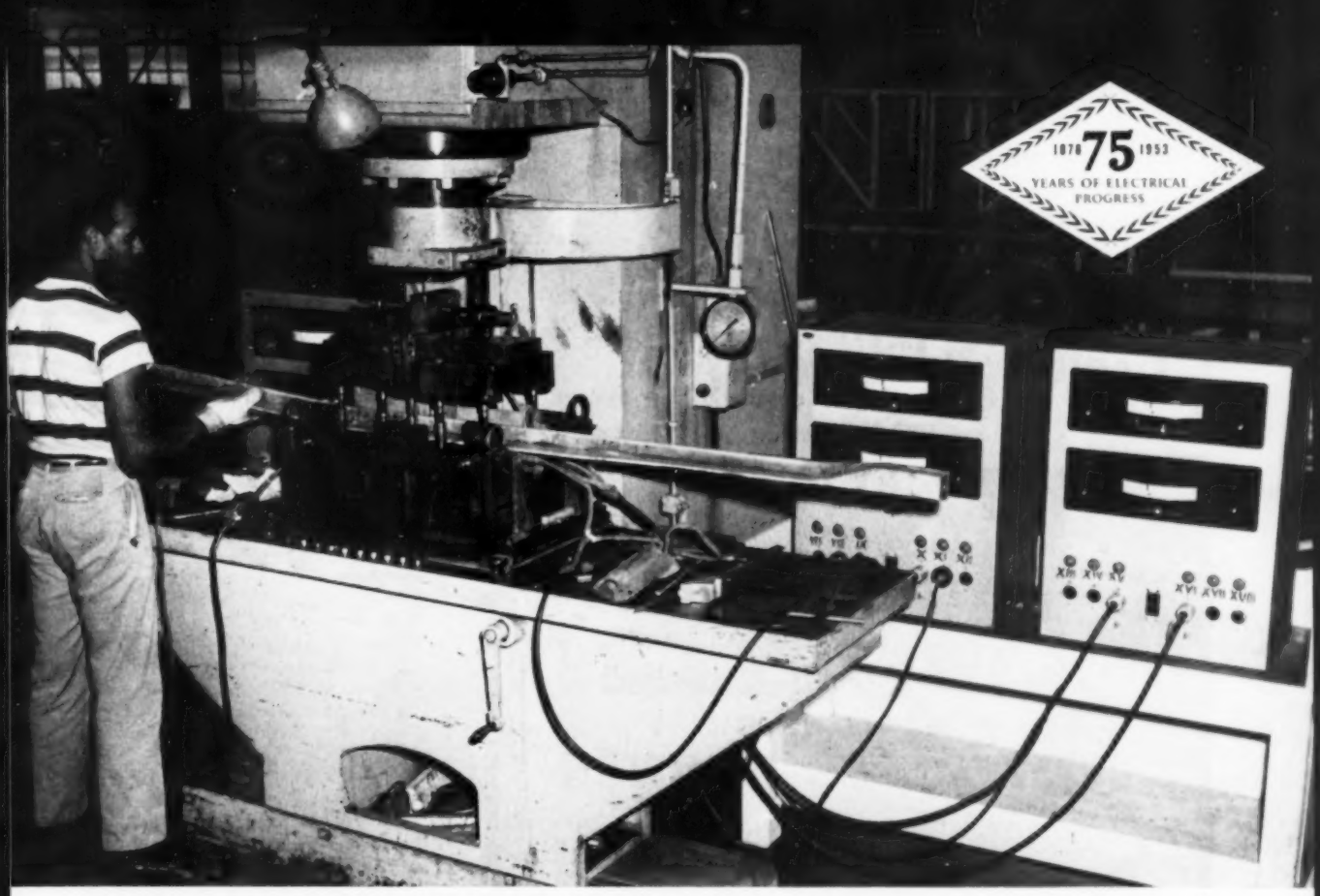
Variety of Uses – Field applications of the austenitic alloy include screw conveyers, chutes, feed spouts and pipeline fittings where wet or dry abrasive particles are handled. Agricultural machinery parts can be protected from soil erosion by use of the alloy. Hard facing of pump runners, flotation mill impellers, brick and clay plant machine parts and cement mill components effectively lengthens their life. However, where impact, crushing or grinding are involved, caution should be exercised, since the martensitic high-chromium iron in the long run may be more economical.

The austenitic grade has found many uses where metal-to-metal wear is encountered. Examples are tractor clevis connections, high-speed drive sprockets, cement mill driveshaft bearings and bushings; drag chain links, pins, rider blocks and idlers; friction clutches on lumbering equipment, railway car retarder parts, steel mill guides, barrels for wire coilers, pinch rolls, wire straightener rolls and piercing points.

Hot hardness up to 1000° F. is fair, falling markedly beyond that

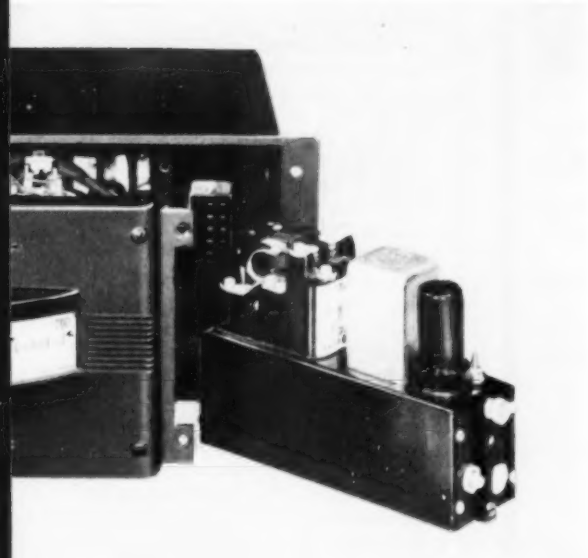
(Continued on p. 138)

*Digest of "Hard-Facing Alloys of the Chromium Carbide Type", by Howard S. Avery and Henry J. Chapin, *The Welding Journal*, Vol. 31, October 1952, p. 917-930.



OPERATOR REMOVES AIR-FRAME MEMBER FROM PRESS. SIX G-E PYROMETERS KEEP THE DIE TEMPERATURE CONSTANT.

G-E Pyrometers Provide Inexpensive Control For Process Die at Douglas Aircraft Co.



PLUG-IN UNIT is readily accessible for any maintenance checks. The cover is easily removed and the unit pulled out. Standard vacuum tube is shown on right end of unit.

Douglas Aircraft Company, Santa Monica, Calif. is currently using six G-E pyrometers to control an electric die which is used in a hydraulic forming press. To relieve stresses which might be set up during the forming process, the aluminum members are first heated in a furnace and then placed in the electrically heated die. The temperature of this die is kept constant by the G-E pyrometer equipment. Accurate control of the die must be maintained as each member in its finished state is worth about $2,000.

THE G-E PYROMETER is a two-position (on-off) direct-deflection millivoltmeter type. Besides being one of the least expensive types of automatic control, the General Electric pyrometer employs an extremely simple and reliable construction, thus assuring dependable operation.

STURDY CONSTRUCTION throughout makes the G-E pyrometer equipment rugged and vibration resistant. Two of the features which assure low maintenance cost are: a readily accessible plug-in control unit, and a standard vacuum tube which permits easy and low-cost replacement.

MORE INFORMATION is available from your nearest G-E apparatus sales office or write for Bulletin GEC-713, General Electric Co., Section 602-248, Schenectady, N. Y.

You can put your confidence in—

GENERAL ELECTRIC

Survey of High-Chromium Alloys for Hard Facing

(Continued from p. 136)

point. High chromium content confers excellent scaling resistance; the deposits are commercially unmachinable and are difficult to grind.

Martensitic Grades – Many hardenable types of high-chromium irons have found use for wear applications, both in the form of castings and for hard facing. The compositions cover a range from about 2% C and 20% Cr to 5% C and 35% Cr. A basic type is the HC250 composition which the alloy casting industry has produced in some volume for a number of years. The designation was originated by the Alloy Casting Institute, H signifying a heat-resistant alloy, C indicating the 24 to 30% Cr range, and 250 the 2.5% C.

The alloy can be used as-welded, but shows best wear resistance by heat treatment in the 1750 to 2100° F. range followed by air cooling to produce a martensitic structure in the matrix. This develops hardness of Rockwell C-54 to 62 and a 40 to 74% increase in high-stress abrasion resistance over that of the austenitic high-chromium irons. Compressive yield strength above 150,000 psi. may be obtained, providing resistance to light impact and galling.

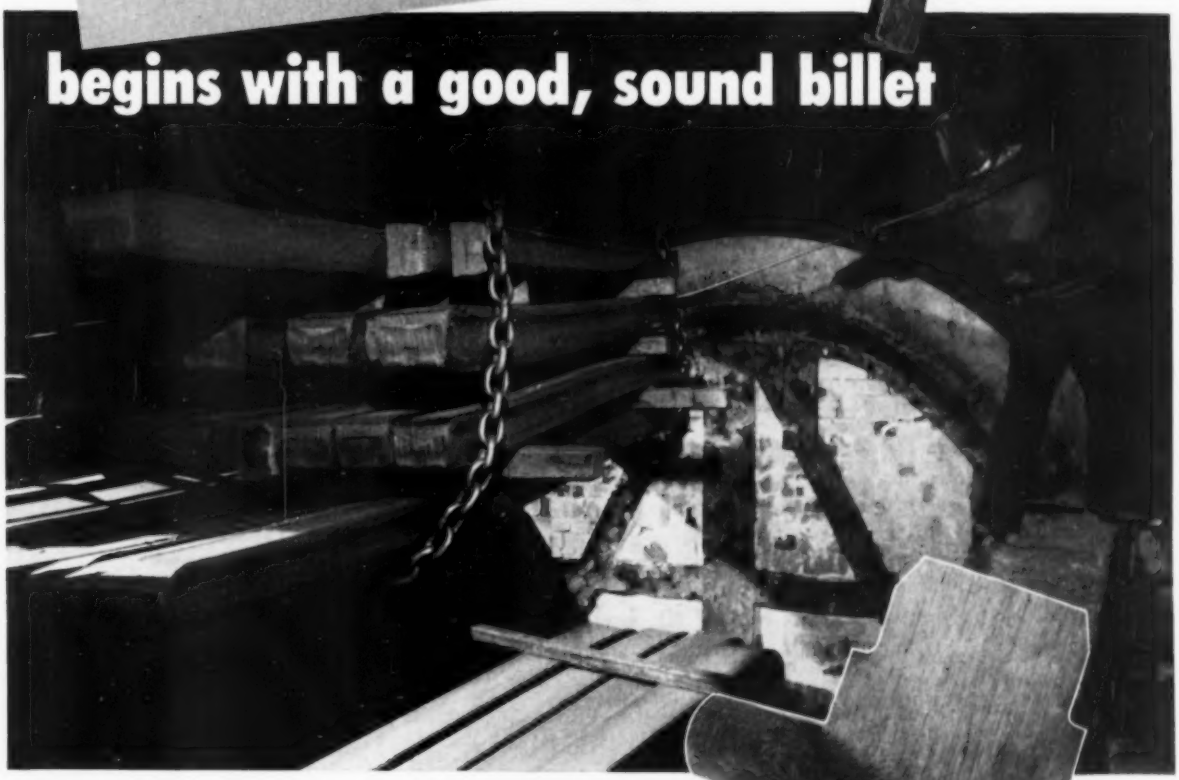
The effectiveness of heat treating the HC250 alloy for improving resistance to high-stress grinding abrasion is apparently not too widely recognized and field experience is scant in comparison with that available on the austenitic hard-facing alloys. In one series of tests involving high-stress grinding with wet quartz sand, the HC250 alloy, gas welded, showed a weight loss factor of 0.47 after heat treatment, compared with 0.72 for the as-welded sample. The heat treatment was at 1400° F., 3 hr. air cool, followed by 2100° F. and 2 hr. air cool. A specimen with $\frac{3}{8}$-in. thick arc welded deposit, similarly heat treated, gave a loss factor of only 0.32.

Annealing Procedure—The HC250 alloy can be softened somewhat for machining, an unusual characteristic for high-carbon hard facings. Annealing 12 to 24 hr. at 1400 to 1450° F., followed by furnace or air cooling, may bring hardness below Brinell 340 in the case of arc welded deposits where some carbon usually is burned out. Gas welded deposits, made with a carburizing flame which increases carbon content, can be annealed only to Brinell 400 to 450.

(Continued on p. 140)

Successful Forging

begins with a good, sound billet



At Bethlehem we take unusual care in producing alloy steels for forging purposes.

Chemical composition and grain size are closely controlled so that the forgings will respond to heat-treatment uniformly with minimum distortion. Billets are cooled slowly in bung-type furnaces, with separate cooling cycles being used for each composition, to avoid cooling cracks. Rolled billets are subjected to macro-etch tests to insure internal soundness. Nothing is overlooked that might improve the overall quality.

Bethlehem Alloy Steels will go a long way toward helping you turn out a higher percentage of acceptable forgings. We manufacture all of the AISI grades, as well as carbon and special steels.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM ALLOY STEELS

Survey of High-Chromium Alloys for Hard Facing

(Continued from p. 138)

Annealed structures are more machinable than these hardness levels suggest. Tungsten carbide tools are advisable because of the hard carbides present. After machining, the alloy should be hardened for use, the resultant structure being so abrasion-resistant that subsequent machine grinding to size is not feasible. Accurate sizing should be carried out in the machining operation.

The two alloys are logical alternates for the costlier high-carbon alloys of chromium-cobalt-tungsten, provided corrosion resistance or hot strength above 1000° F. is not a critical factor. At atmospheric temperatures they may even out-perform the more expensive materials in hard-facing service.

A. H. Allen

Effect of Deformation on Martensite Transformation*

Earlier studies by the authors which were made of steels and carbon-free alloys having martensite points near 0° C. (32° F.) have shown a qualitatively similar picture – a preliminary plastic deformation which ranged from 2 to 70% compression at room temperature increased the stability of austenite relative to later extreme cooling, this effect being more pronounced with increasing deformation.

The rate of transformation of austenite to martensite decreased at all temperatures as a result of prior plastic deformation. This result was thought inconsistent with the authors' understanding of the change of the stability of austenite with increasing deformation, according to which a slowing action by deformation would be expected at relatively large deformations because of a tendency toward less extensive coherency between the austenite and martensite lattices. At low deformations, therefore, the rate of martensite formation should be increased because of an increase in potential sites for nuclei.

To shed light on this question, careful experiments were performed on steels 50N23 (0.5% C, 23.5%

(Continued on p. 142)

*Digest of "Influence of Deformation on the Kinetics of the Martensitic Transformation", by O. P. Maksimova and A. I. Nikonorova, *Doklady Akademii Nauk SSSR*, Vol. 81, 1951, p. 183-186.

The New Louisiana Purchase

EVERY day America crosses a frontier—the frontier of a new market. It is the market created by an ever growing population. Since Pearl Harbor, our population has increased 23½ millions—more than all the people now living in the region west of the Mississippi once called the Louisiana purchase, that vast billion-acre area which provided us with geographical frontiers for a hundred years.

During 1952, 8,500 babies were born daily, increasing our population by nearly 3,000,000 people. New families and bigger families need more and bigger houses, more food, clothing, cars, roads, hospitals, churches, schools. Their needs call for continuing and increasing production from farms and factories.

There are those among us who say a decline in government spending will bring depression. But where is there room for depression when we add the population of another Minnesota or an Iowa to our nation each year—when the need for goods and services increases steadily? In fact, only by tapering off our vast programs of government spending can industry and business hope to provide sufficient goods to maintain our present standard of living and satisfy the demands of our ever growing population.

Let no one tell you America has crossed its last frontier.

QUALITY YOUNGSTOWN SERVICE

The Youngstown Sheet and Tube Company

General Offices--Youngstown 1, Ohio
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MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

RAILROAD TRACK SPIKES - CONDUIT - HOT AND COLD FINISHED CARBON AND ALLOY BARS - PIPE AND TUBULAR PRODUCTS - WIRE - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RODS - SHEETS - PLATES.

Effect of Deformation on Martensite Transformation

(Continued from p. 140)

Ni), 100M3 (1.0% C, 2.7% Mn), and 60N18 (0.6% C, 17.5% Ni) which have martensite points of −90° C. (−129° F.), −15° C. (5° F.), and 7° C. (44° F.), respectively. Austenitized specimens of these steels were compressed 0 to 60% at room temperature, and then the amounts of martensite that formed on continuous cooling to as low as −200° C. (−328° F.) were determined. These results showed that the rate of transformation is increased by deformations up to about 20%. The amount of deformation at which the accelerating effect was greatest was larger the lower the martensite point of the alloy, and was 15%, 7%, and 3%, respectively, for the alloys listed above.

The temperature of the martensite point of alloy 50N23 increased rapidly at first and then more slowly with increasing amount of deformation to about −75° C. (−103° F.) at 40%. The other alloys showed corresponding decreases in their martensite points, −25° C. (−13° F.) for 60N18 and −45° C. (−48° F.) for 100M3.

A. G. Guy

Problems in Central-Station Nuclear Power*

THIS PAPER STRESSES the basic problems associated with the building of plants for central-station nuclear power to compete commercially with the conventional sources of electrical energy, water power and coal. Four principal technical problems confronting the reactor designer listed are: *(a)* Choice of systems for transferring the heat generated by the fission process in the reactor to a turbogenerator unit to make electricity, *(b)* choice of materials of construction and their susceptibility to radiation damage, *(c)* development of efficient and cheap processes for the chemical processing of irradiated fuels to recover the fissionable material in usable form, and *(d)* choice of plant location so that central-station nuclear-power plants do not need to be located necessarily on extensive government-owned reservations, even though large quantities of radioactive fission products are involved.

*Digest of "Basic Problems in Central-Station Nuclear Power", by W. H. Zinn, *Nucleonics*, Vol. 10, September 1952, p. 8-14.

Frequent reference is made to these four technical problems as the author discusses three general methods for the production of central-station nuclear power. The first method involves a nonregenerative reactor wherein the U^{235} is consumed and only heat is produced. It is estimated that cost of electricity produced with this reactor would be 7 mills per kw-hr. for fuel alone. The cost of the fuel for conventional coal-burning generating plants is more nearly 3.5 mills per kw-hr.

The second method described utilizes a regenerative reactor wherein by the time all of the nuclear fuel (U^{235} or thorium) is consumed, 80% as much additional fissionable material (plutonium or U^{233}) is formed. The use of a regenerative reactor, a converter, brings the cost of the nuclear fuel down to 1.3 mills per kw-hr. which is significantly below 3.5 mills per kw-hr. for the cost of coal in a steam-electric plant. This reduction in cost of fuel makes available extra money for the construction of the nuclear portion of the generating station.

The third method involves a breeder reactor wherein more fissionable material is produced than is consumed. By the use of such a reactor, it is estimated that the cost of the nuclear fuel would be only 0.013 mills per kw-hr. However, in a breeder the fuel which is charged into the reactor will have to be removed, after a period of operation, chemically repurified, and replaced. Even if such chemical processing raises the cost of the uranium as fuel by a factor of ten, the cost of fuel for the breeder is still approximately thirty times less than the cost of coal for conventional power plants.

Although the breeder-type reactor in principle results in a low cost of nuclear fuel, it is not known for certain that such a reactor can be operated. Before the fundamental feasibility of the breeder process can be assured, it becomes necessary to build experimental reactors in which appropriate measurements can be made to check this process. The first experimental power plant designed to give over-all information on the breeding process was put into operation by the University of Chicago's Argonne National Laboratory at the National Reactor Testing Station, Arco, Idaho. This reactor is called the Experimental Breeder Reactor and its operation is believed to constitute the first generation of electricity from atomic power. The power output is sufficient to operate all the facilities of the reactor and its building. *(Continued on p. 144)*

Central-Station Nuclear Power

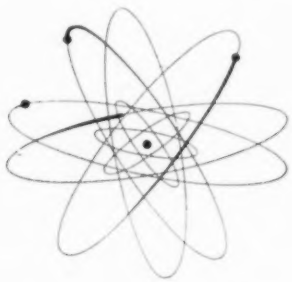
(Continued from p. 143)

The reactor consists of nearly all-metal and fissionable material, with no moderator and with a blanket of U^{238} surrounding the core. A sodium-potassium alloy is used as the coolant. This reactor releases 4 kw. per cu.in. of the core, which is seven times the power density of a high-pressure oil-fired naval boiler, five times the power density of a turbojet engine combustion chamber, and 1/7 the power density of a V-2 rocket which dissipates its energy in a few seconds. Thus, the experimental breeder reactor to date indicates that there is a possibility of realizing the large potential energy in nuclear fuels such as uranium and thorium.

If this large energy can be realized, the economic feasibility of these nuclear fuels becomes a question of major importance. For the first type of reactor discussed, where separated U^{235} is consumed and only heat is produced, even a capital cost-free plant cannot compete with a coal-burning plant. In order for the regenerative or converter reactor to compete with a coal-burning plant, it is estimated that the permissible cost of the nuclear installation can be $45,600,000, with a maximum of $65,600,000 for the total nuclear steam-electric plant. Neglecting chemical processing cost, the permissible amount for the nuclear installation for the breeder reactor is $60,800,000, with a maximum of $80,800,000 for building the entire plant. The big question is whether or not the converter or breeder-type plant can be built for these sums. The answer is not readily apparent, but no amount of paper work can substitute for actual experience in answering this economic question.

Even though it cannot be concluded that economic nuclear power could be achieved now, it is also quite definite that there is no reason to be pessimistic about its ultimate practicability.

V. P. Calkins



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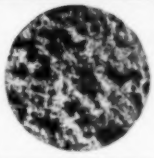	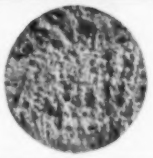

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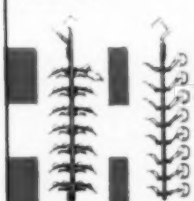

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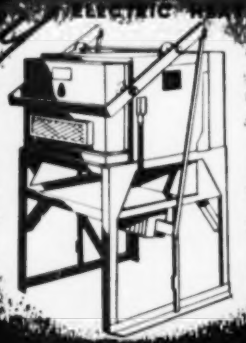

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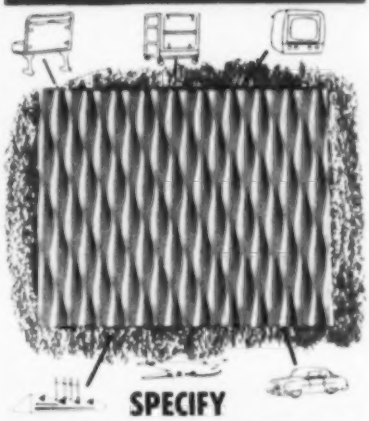

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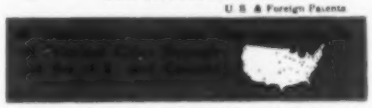

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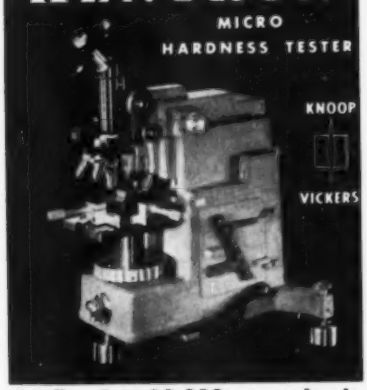

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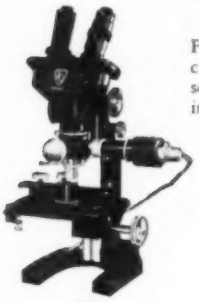

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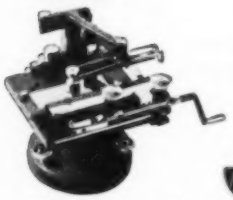

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New Interpretation of Failure by Fatigue*

PREVIOUS STUDIES of the mechanism of failure by fatigue have tended to show similarities in the character of deformation occurring under static and cyclic stressing. In this paper the authors have made an important departure from this viewpoint by emphasizing what they consider to be fundamental differences in the deformation occurring under these two types of loading.

By means of X-ray diffraction methods, the response of polycrystalline copper and aluminum specimens to static stressing was compared with their response to cyclic or fatigue stressing. Cyclic stresses were applied uniaxially to the specimens and had zero mean stress. One important difference brought out in the investigation was termed the "reorientation effect". On comparison of the disorientation produced by equivalent amounts of direct and reversed strain, it was found that in cyclic plastic deformation the reversal of the strain in the second half of the cycle tended partially to restore the disorientation produced by the first half, whereas continued deformation in one direction produced progressive disorientation and breakdown of the structure.

Comparisons were also made of the degree of disorientation caused by slow and by rapidly applied cyclic stress. Thus, a single slow-stress cycle produced a certain degree of reorientation, but distinct disorientation remained. The same stress cycle applied to a similar specimen at high speed produced practically no disorientation and there appeared to be a critical rate of stressing above which suppression of the disorientation set in abruptly. For copper this critical rate was between 300 and 400 cycles per min. at room temperature. The magnitude of the applied stress did not appear to have any large influence on this critical rate, although there was some slight tendency for the critical rate to increase when the stress was made longer. The authors suggest here that the grain boundary may act as a viscous "container" of higher strength than the interior of the grain, and that it gives way under stress only after a distinct interval of

(Continued on p. 164)

*Digest of "Some New Observations on the Mechanism of Fatigue in Metals", by W. A. Wood and A. K. Head, reprint from *Journal* of the Institute of Metals, Vol. 79, Part 2, 1951.

New Interpretation of Failure by Fatigue

(Continued from p. 162)

time. (This explanation does not appear to be wholly satisfactory, because if it were accurate one would expect to find a distinct upper and lower yield point effect for the metal in static tension. Previous studies of the tensile behavior of relatively pure copper have shown the existence of a rate effect but no such yield point has been reported.)

X-ray analysis of structural changes occurring finally at fracture by cyclic stress, whether applied rapidly or slowly, indicated that there was no accumulation of the internal breakdown and disorientation of grains at all comparable with that produced by progressive unidirectional deformation. It is suggested that reorientation and the critical speed for suppression of disorientation are the effects which underlie the characteristic differences in mechanical behavior of a metal under static and fatigue stressing.

This is an important continuation of the series of papers initiated by Dr. Wood on the elastic and plastic behavior of metals.

G. M. SINCLAIR

Limit of Carbide Solubility in 18-10 Stainless*

THE AUTHORS have manufactured high-purity 18-10 Cr-Ni stainless steels corresponding to commercial Types 304 ELC, 304 and 302 with carbon ranging from 0.007 to 0.30%, using vacuum melting techniques. Two-pound ingots were hot forged, annealed at 1975° F., and finished to a ½-in. round, half of which was cold drawn somewhat. Both parts were then held at 800° F. for six weeks to precipitate excess carbides, and their quantity estimated micrographically. Samples were then heated at progressively higher temperatures to dissolve as much of the carbide as the austenitic crystals could hold at the given temperature. Micrographic analysis was complicated by the presence of ferrite and sigma, especially sigma in the lower carbon alloys at 1000 to 1300° F.

At 1350° F. all carbide in the 0.007% carbon alloy had dissolved.

(Continued on p. 166)

*Digest of "Solubility of Carbon in 18% Chromium, 10% Nickel Austenite", by S. J. Rosenberg and Carolyn R. Irish, Research Paper 2281, National Bureau of Standards.

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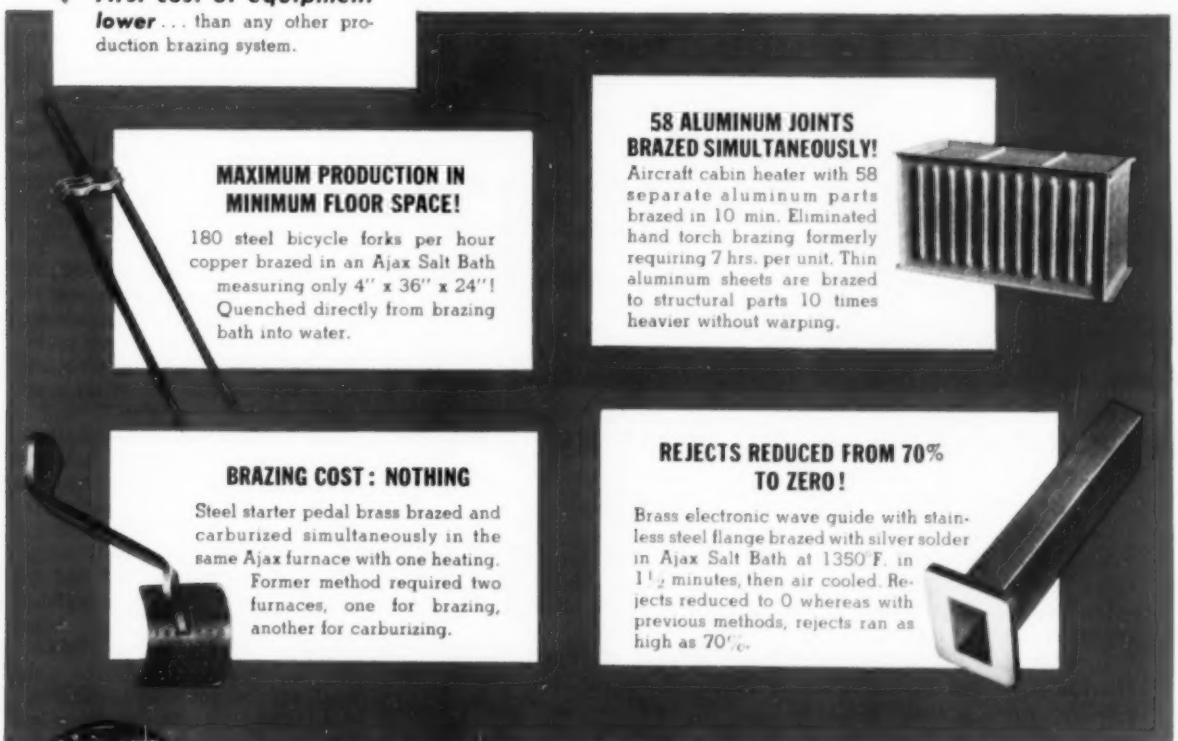

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Limit of Carbide Solubility in 18-10 Stainless

(Continued from p. 164)

Solubility of carbon in austenite increased linearly with temperature, reaching 0.08% at 1975° F. These figures are much lower than usually stated. For example, the limit of solid solubility of carbide in austenite, shown in a diagram for 18% Cr, 8% Ni by Krivobok (p. 47, "The Book of Stainless Steels"), is 0.02% at 1200° F., and 0.24% at 2000° F. On page 550 of Metals Handbook is a diagram connecting constant corrosion rate of 19 Cr, 9 Ni (assumed to occur for solid solutions with no free carbides at the grain boundaries), and it shows 0.02% at 1200° F., and 0.155% at 2000° F.

The annealing of austenitic stainless steels is often governed by the desire to obtain a completely austenitic structure. To attain this end, commercial practice utilizes relatively high annealing temperatures, about 1950 to 2000° F. From another standpoint, however, such high annealing temperatures are undesirable; annealing at lower temperature results in smaller grain size, which is thought to reduce susceptibility to intergranular embrittlement. Since the temperature at which all carbon is in solution increases with carbon content, it seems to follow that low-carbon steels may be annealed at lower temperatures than the higher carbon varieties.

Again, the use of Type 304 ELC steels in industry is based on the premise that the low carbon content (0.03% max.) will give some protection against intergranular embrittlement after heating within the range of about 800 to 1400° F. and is either simultaneously or subsequently exposed to the action of certain corrodents. Intergranular embrittlement has been plausibly ascribed to the precipitation of chromium carbide at the grain boundaries of the austenite, and it has been proposed that the phenomenon might be completely inhibited by reducing the carbon content to less than the limit of solubility at temperatures to which the steel will be subjected. Although these extra-low-carbon steels are less susceptible to intergranular embrittlement than the higher carbon varieties, the investigation at the Bureau of Standards indicates that it is impracticable, if not impossible, to produce steels with carbon contents sufficiently low to insure freedom from carbide precipitation under all conditions of service.

E. E. T.

HEAT TREATING MATERIALS . . . SINCE 1911

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BY THE *Research Laboratory* OF THE PARK CHEMICAL CO.

DETROIT 4, MICHIGAN

Tests Show New Quench Oil has Intensified Triple Action

PARK'S Triple A Quench Oil has intensified triple action: 1. Rapid heat removal with faster cooling rate in the critical range giving higher and deeper hardness. 2. Slow cooling through the hardening range, minimizing distortion. 3. Great stability due to special anti-oxidants. Result is longer life and bright quenching properties.

An explanation of the quenching process illustrates how Park Chemical Company with over forty years of chemical and metallurgical background developed an ideal oil to fit the ever mounting production quenching problems.

Three stages of cooling are observed when steel is quenched in oil from a red heat. (A) Formation of a vapor film at the steel surface; cooling is accomplished by conduction and radiation through this vapor film and is relatively slow. (B) Direct contact of the oil with the metal surfaces causing a boiling action which continually dissipates the vapor film formed and results in rapid cooling. (C) After the metal has been cooled to the boiling point of oil, vapor is no longer formed; cooling is by conduction and convection, and the metal slowly cools to the temperature of the oil.

Although water and water solutions provide high cooling rates throughout these three stages of quenching, they are often impractical because rapid cooling is not desirable in the lower ranges of temperature where martensite is formed. It is at this time that temperature differentials within a piece of steel cause warping and cracking. Thus oil quenching is preferred for all steels possessing sufficient hardenability to avoid transformation to soft structures in stages A and B, since the cooling rates furnished by oils during Stage C are ideal for preventing temperature differentials.

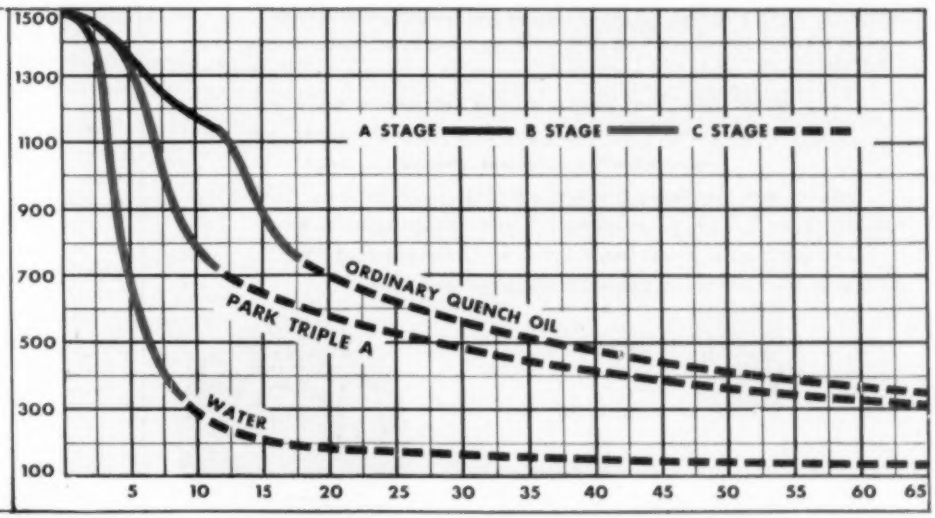
It is apparent that any improvement in the cooling power of oil in Stages A and B would be most desirable. Such improvement is obtained in water quenching by the addition of salt or caustic soda. The brine or caustic solution has a wetting action which completes the quenching job faster than fresh water. Fresh water takes hold only in spots causing non-uniformity. Brine solutions provide deeper and more uniform hardnesses. It seems logical to attempt to do this same thing with oil. The mineral intensifiers added to Park's Triple A Quenching Oil act in this manner.

The accompanying cooling curves serve to illustrate how this additive has altered the quenching power of the oil in the A and B stage, yet has retained the desirable slow cooling in the C stage.

This is the front page of a 4 page Technical Bulletin on Oil Quenching. For the complete bulletin write for Bulletin F-8.

A, B, C, stages in cooling curves showing advantages of Park Triple A Quench Oil. Samples quenched from 1500° F. in oil at 140° F. and water at 70° F. Steel SAE 1045 ½" dia. x 2" long.

Note: Chart is plotted in degrees F. on the ordinate and time in seconds on the abscissa.



PARK CHEMICAL COMPANY, 8074 MILITARY, DETROIT 4, MICH.

Comparative Results of Three Stress-Relief Methods*

IT WAS RECOGNIZED at an early date that a steel plate containing a weld does not perform as well under most conditions as one which has not been welded. This is particularly true when notches are encountered at low temperatures. Early investigators found that annealing at 1700 to 1800° F. restored almost all the properties of the original plate. However, this is not always practical; and a compromise treatment was eventually adopted. This consists of a post-welding heat treatment at 1200° F., followed by furnace cooling. This treatment also suffers economic disadvantages, and further research has led to the development of the low-temperature preheating treatment. In 1947 the author and his colleagues reported the comparative properties of welded specimens preheated to 400° F. with the properties of similar specimens postheated at 1000° F. The preheated specimens had better properties.

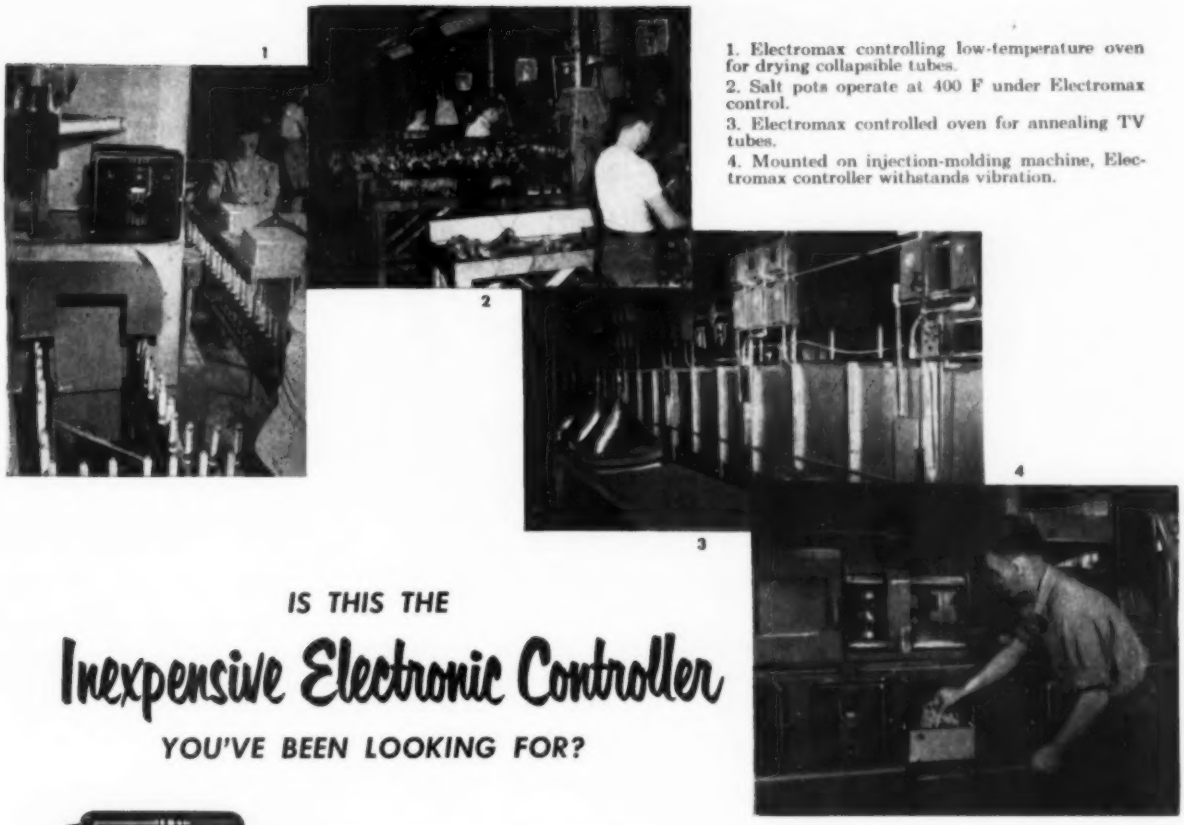
In 1948 T. W. Greene developed a "controlled, low-temperature stress-relief" treatment which improved the properties of the as-welded specimen, but not to the same extent as the 1200° F. postheat treatment. However, there does not appear to have been any tests carried out which would provide a direct comparison between these methods of heat treatment; namely, *(a)* preheat, *(b)* controlled low-temperature stress relief, *(c)* post welding heat treatment at 1200° F. The author, therefore, designed an experiment to compare the above three methods.

Specimens were two steel plates butt-welded using a single V edge preparation. Charpy V notches were made in each specimen on the root side of the weld and transverse to the weld length. Eight specimens were made, and two were taken to represent each condition; that is, as-cast; 400° F. preheat; 1200° F. stress relief; controlled low-temperature stress relief.

It was found that all the treated specimens performed better than those in the as-welded specimens. The preheated and 1200° F. postheated specimens were more ductile than the low-temperature stress-relieved specimens. One factor which may be partially responsible

(Continued on p. 170)

*Digest of "Preheat vs Low and High Temperature Stress-Relief Treatments", by E. Paul DeGarmo, *Welding Research Council*, May 1952, p. 233-238.



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instruments automatic controls • furnaces

Stress-Relief Treatments

(Continued from p. 168)

for this is that the heat-affected zone of the preheated specimen was much wider than the corresponding zones of the others.

Metallographic examination showed that the transition from the heat-affected zone to the normal metal was more gradual in the specimens preheated and postheated at 1200° F. than in as-welded and low-temperature stress-relieved specimens.

Since no apparent metallurgical change could be found to account for the improved properties of the specimens stress-relieved at low temperature, the answer was sought by measuring residual stresses in specimens which had been preheated and low-temperature stress relieved. These stresses were found to be higher in the former case, although this method gives the better performance. Therefore, the explanation advanced by Greene – that the improved performance of the low-temperature stress-relieved specimens was due to the virtual absence of residual stresses – does not appear to be valid.

The author believes that consideration should be given by the various agencies to alter the codes to allow 400° F. preheat as a substitute for the conventional 1200° F. postwelding stress-relief treatment.

R. C. SHNAY

American Iron and Steelmaking Practices Compared With British*

THE GENERAL STORY of the first chapter can be summarized as follows. The material standard of living in America is probably twice as high as that of any European country. This is reflected in a correspondingly high consumption of steel, to which consumption the development of public and private transport, of skyscrapers and of the mechanized kitchen have all contributed. This highest standard of living is partly the outcome of historical forces and the character of the American people; but its indispensable foundation was the coun-

(Continued on p. 172)

*Digest of the Productivity Report, "Iron and Steel", June 1952, 147 p., published by the Anglo-American Council on Productivity, copies available from Office of Technical Services, Dept. of Commerce, Washington, D. C. Price on application.

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A product of **PITTSBURGH STEEL COMPANY**

Steelmaking Practices Compared With British

(Continued from p. 170)

try's exceptional natural resources — the enormous and pure reserves of iron ore in the Lake Superior region and of coking coal in the Allegheny Mountains, linked by the natural waterway system of the Great Lakes district.

Geographical concentration by district is matched by a concentration of output in large works, encouraged by the great distances involved, which made necessary a substantial investment in large-scale transport. The perennial shortage of labor in relation to resources encouraged mechanization; the market is very large and highly standardized; and intensive competition has stimulated both the amalgamation of firms and investment in sources of raw materials. Finally, a high proportion of the American industry is of recent construction, thanks not only to the rapid expansion of the population and the economy, but also to Government investment and tax concessions for defense purposes.

CHAPTER 4

The higher furnace productivity in America is due mainly to the large sizes of the furnaces and the faster driving rates. New furnaces built for basic iron should normally be of not less than 25-ft. hearth diameter for imported ore and 27-ft. diameter for British ore.

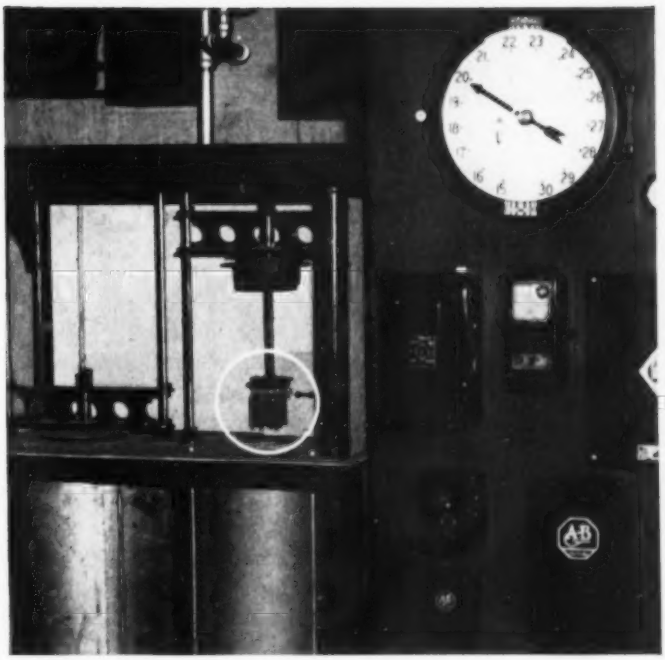
Britain needs greater control of imported ore supplies, and particularly of sea transport facilities. These are necessary to provide increased tonnages of high-grade ore at minimum cost. Improved distribution of the various grades of imported ore in relation to blast furnace use would increase iron output and reduce coke consumption by minimizing the excessive number of burden changes now necessary. Also, a wider application of efficient ore preparation and agglomerating processes would be beneficial.

There is room for improvement in the size distribution and bulk density of blast furnace coke, through better coking technique, more elaborate screening, layer charging and improved handling. An investigation should be undertaken to determine more precisely the factors which limit the driving rate of British furnaces.

Productivity in the foundry iron section of Britain's industry is very

(Continued on p. 174)

SCALING RESISTANCE EVALUATED AT HIGH TEMPERATURES



High-Temperature Corrosion Often Is the Main Factor in Metal Failure

Learning why metals fail at high temperatures – determining the actual cause of damage and suggesting as a remedy a more suitable material—these are the jobs of INCO High-Temperature Engineers, who are getting information on such problems for the use of industry.

INCO laboratories in Bayonne, N. J., and Huntington, West Va., have useful data on the properties of metals at elevated temperatures. This information comes from tests made to determine the creep strength, stress-rupture, and other properties of materials at temperatures in some cases up to 2100°F.

Industrial experiences at high temperatures indicate that it is unwise to predict high-temperature performance on the basis of room-temperature properties or short-time high-temperature tests. Other methods have been developed that provide more accurate measures for judging materials.

The machine pictured above was especially designed by INCO Engineers for determining the effect of cyclic heating and cooling on sheet metals while exposed to oxidizing conditions. INCO High-Temperature research likewise covers damage by other corrosive atmospheres. Through work with this and other types of equipment INCO Engineers study the reasons for failure of alloys at high temperatures.

Due to the volume changes accompanying its formation, an oxide film formed at high temperatures on the surface of a metal or alloy is usually under compressive stress. Contraction stresses developed when the underlying metal is cooled further aggravate this situation – and with many alloys may cause rupturing of the normally protective oxide.

Among the factors which influence the resistance to oxidation, the physical characteristics of the formed scale are of importance. The sketches show how these characteristics may cause the breakdown of the scale and thus increase the rate of oxidation.

Blistering may occur in oxide layers having good elasticity but poor adherence to the metal surface.

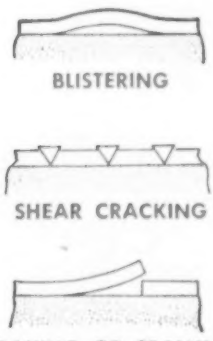
Shear cracking on the other hand will be found in oxides that are adherent but relatively brittle.

Flaking or spalling results when the oxide is both brittle and non-adherent.

As the scale peels away from the metal, it exposes a fresh area to further attack. A point of importance is that the loss of the oxide causes a progressive loss in metal section—useful load-carrying metal.

In high-temperature applications employing sheet or strip, the necessity of obtaining maximum resistance to this form of destruction by selection of a suitable heat-resisting alloy is of greatest importance.

Oxide Scale Breakdown by:



If high-temperature alloy performance is a problem to you, whether in present activities or in new projects, INCO High-Temperature Engineers will do their best to be of help to you. Let them send you the *High-Temperature Work Sheet* . . . it is a big aid in explaining your situation fully. Then see if INCO Engineers cannot help solve your difficulty.

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Steelmaking Practices Compared With British

(Continued from p. 172)

low, mainly because of the large number of small furnaces in use. Considerable concentration of production into larger units, using prepared ore, should be possible. The reasons for the large number of foundry iron specifications and the higher proportion of foundry iron in the total British production as compared with American ought to be examined.

CHAPTER 5

The patterns of the British and American steel industries are very different, since in Britain much more scrap is used and the iron has higher phosphorus and sulphur contents. This results in the operation of different basic openhearth processes.

The cold metal process accounts for 42.8% of capacity in Britain and only 9.2% in America. Yet the average furnace and labor productivities in Britain using this process are about one half those in America, owing mainly to the existence in Britain of a large number of small furnaces driven at a low rate, and to a higher shift manning.

The hot metal process employing fixed furnaces accounts for 34.5% of the capacity in Britain and 77.4% in America. Improvements in the productivities in this process can be obtained by providing larger furnaces and more handling equipment, and by using fewer men. The tilting process, which is becoming more dominant in Britain in order to deal with high-phosphorus iron, has a creditable productivity performance. Its driving rate could, however, be increased, possibly by the introduction of some intermediate refining.

Very high productivities are obtained in America by the use of the acid duplex process, and where conditions are favorable this should be re-introduced in England.

Furnace design and methods of control are probably more advanced in Britain than in America, as indeed they must be to maintain the high quality of British steel, despite the inferiority of its raw materials (compared with American).

American melting shops are better laid out for ease of maintenance. In addition, the American maintenance worker is provided with many effective mechanical aids. As a consequence, the maintenance man-

(Continued on p. 176)

Closer Temperature Control, Cleaner Aluminum, Cooler and Less Congested Conditions Are Obtained With

AJAX TAMA-WYATT *Induction Furnaces*

Thousands of die-cast rotors for hermetic motors are made from pure aluminum poured from a battery of AJAX Electric Induction Furnaces installed in the St. Louis plant of the EMERSON ELECTRIC MFG. CO. Two of these furnaces are shown in the photograph at right.

Close-up of die-cast aluminum rotor which is pressed onto the compressor shaft extension used in refrigeration units.

Our electrical industry produces fractional horsepower motors at the rate of 20 to 25 millions per year. After World War II the leading manufacturers changed from fabricated copper rotors to cast aluminum rotors. In this operation, aluminum of high purity under closely controlled temperature is required.

In many cases the machines had to be placed right on the assembly line, with severe space restrictions and, of course, rigid requirements for reliability. AJAX induction furnaces and AJAX automatic pouring units were selected for this job in almost all the plants which switched from copper to aluminum rotors.

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AJAX ELECTRIC CO., INC., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

Steelmaking Practices Compared With British

(Continued from p. 174)

power required is much less than in Britain, despite the fact that furnaces are driven harder. The availability of British furnaces is low compared with American achievements. Some improvement could probably be attained with modest capital expenditure, and thus assist in achieving higher output.

CHAPTER 6

The main cause of higher productivity in American rolling mills lies in the nature of the equipment, the rolling mill practice and the type of end-product. There is no substantial difference between America and Britain in the quality or type of steel fed to the mills, except perhaps in the size and weight of ingot, which is somewhat greater in America.

American mill designers have undoubtedly achieved a high standard of mill layout; frequently there are a greater number of independent drives, and therefore a high total horsepower is engaged. The layouts are specially suitable for rolling large tonnages of fairly standardized products. Many mechanical aids have also been developed to obtain faster working of the stock, in order to reduce the manual effort required and thus increase the speed of rolling. Continuous development along these lines is obviously to be recommended for British practice.

Experience in America, and recently also in Britain, has shown that primary mills of high capacity can give a high productivity and a low over-all cost of operation. New primary mills in Britain should have a potential capacity of not less than 750,000 tons and preferably 1,000,000 tons per year, but there are many problems to be solved before this standard of capacity could be generally achieved. The number of mills with such a potential capacity is being increased under the industry's present development plans.

Broad-flanged beams are now being rolled successfully in a British traditional 2-high reversing mill, but the range of size and weight produced is somewhat limited. A high-capacity Universal beam mill of the American type has been proposed for installation in Britain, and this will enable the full range of size and weights to be produced.

It is suggested that serious consid-

(Continued on p. 178)

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Steelmaking Practices Compared With British

(Continued from p. 176)

eration should be given to the American 3-high layout for any future development in Britain in medium-size sections. By the provision of extra stands and drives it is possible, on this type of mill, to roll more bars simultaneously and at higher speed. The manning is reduced to a minimum, since it is possible to provide automatic manipulation devices.

Future plate-mill installations in Britain are being designed with a 2-high break-down stand or broad-siding unit and 4-high working stand in accordance with modern layout in America. The addition of more stands to give higher production rates will depend essentially on the degree of concentration which can be attained within the industry.

The smaller number of sizes rolled in America and the elimination of small tonnage orders and odd sizes from rolling programs is of great advantage to productivity. Steps should be taken in Britain to reduce the number of sizes rolled and thereby increase the tonnage of each.

CHAPTER 7

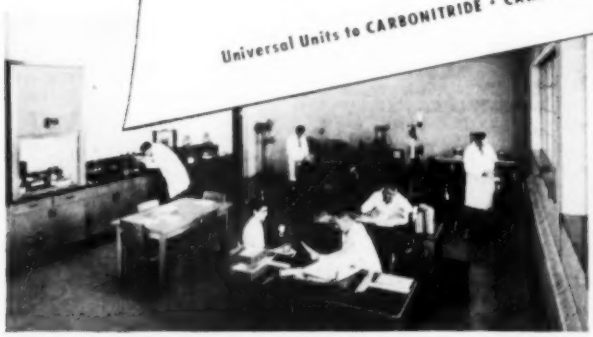
Blast Furnaces — The physical and chemical qualities of American coke are in general better than British. The degree of fuel integration in American works is less in those districts where rich fuels like natural gas and oil are available, and blast furnace gas is therefore not used to any extent.

Openhearth Furnaces — In cold-charged furnaces the fuel consumption per ton of ingots for American units is about 15% lower than in British furnaces. For hot-metal practice the difference between the two countries is of the order of 20%.

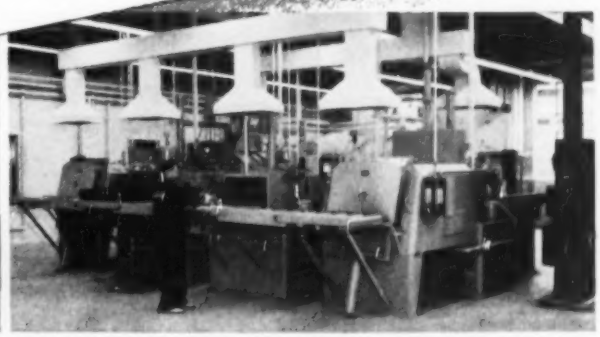
The use of fuels having a high calorific value and the development of high flame temperatures accounts for a reduction of at least 10% in American fuel rates compared with British. Other causes of lower fuel consumption in America are the lower metallurgical load, good furnace design for known fuels and raw materials, and adequate charging facilities.

The use of large furnaces in America reduces the fuel consumed per ton of ingot. The recommendations for minimum furnace sizes (given in Chapter 5) are therefore

(Continued on p. 180)



Skilled Ipsen metallurgists work with instruments of latest design, including induction carbon apparatus, Tukon hardness tester, microscopic equipment and special pyrometric apparatus.



View of shop section of Ipsen Laboratory, showing a portion of the heat treating equipment, which includes 250 and 400 lb. hr. automatic controlled atmosphere furnaces, washers, and tempering units.

Steelmaking Practices Compared With British

(Continued from p. 178)

reinforced by considerations of fuel economy.

Soaking Pits – The fuel consumption in soaking pits is considerably lower in America than in Britain, even when the identical types of modern pits used in the two countries are compared.

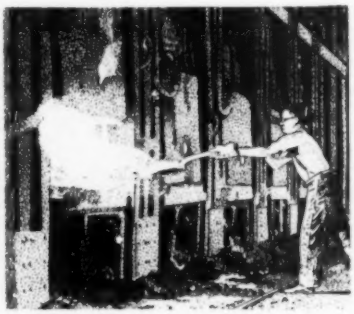
This is due to the high percentage of hot ingots charged, first-class instrumentation, universally applied control gear, and heating programs scheduled in detail with reference to track times and steel quality. Considerable improvement in soaking-pit practice is possible in Britain.

Refractories – The quality of silica bricks used in America is slightly better, and the quality of firebricks considerably better, than in Britain. Basic bricks are of a similar standard in both countries. The use of basic ends on openhearth furnaces, extensive furnace cooling, and the use of archless water-cooled door frames give American practice some advantage over British. Extensive use is made of magnesite ramming mixes for hearth construction, and doors are rammed with plastic basic material. In terms of unit roof-life, British practice is better than American, but linings, basic ends and checkers give better lives on American furnaces.

The larger size of American furnaces in itself reduces the amount of refractories consumed per ton of ingots. However, even when furnaces of similar size are compared, British furnaces consume more refractories per ton of ingots on account of the higher metallurgical load, heavier slag weight and longer refining times. In American practice, both new and repaired furnaces are brought to steelmaking temperature from cold much quicker than in British operations.

E. C. Wright

(Concluded next month)



Conservation Through Progress

(Continued from p. 90)

Notable among these is the "transistor", an amplifier like the vacuum tube, and the "diode", a rectifying and modulating device. The transistor and the diode are now made from single crystals of pure germanium or silicon a little larger than the head of a pin. Impurities are controlled to one part in a hundred million. These new devices operate on a few thousandths of a watt in contrast with a few watts for the vacuum tube and require on the order of 5 volts in contrast with 100 volts for the vacuum tube. This reduction in size, power and voltage opens up many new uses that have not been penetrated by vacuum tubes. Looking ahead, Dr. Kelly anticipated that they will play an important role in local transmission and in interconnection or switching. They will also be of great importance in military electronics; their ruggedness, low power consumption, long life, and miniature size make them especially important in airborne equipment. In the field of computers and accounting machines they will have great industrial importance beyond the bounds of the communications art.

Large Pressings, Forgings and Extrusions

(Continued from p. 114)

General extrusion practice is to maintain cylinder temperature lower than the ingot temperature. This facilitates starting the extrusion when the pressure requirement is at a maximum, because of inertia and maximum contact between ingot and cylinder. After extrusion has progressed and the pressure requirement decreased, the colder cylinder absorbs the heat generated, thus maintaining a more uniform heat balance throughout the cycle.

To derive maximum benefit from large extrusion presses, auxiliary equipment such as heat treating, preheating and reheating furnaces and straightening machines must be available. Preheating was defined as a high-temperature treatment preliminary to hot working, and takes sufficient time so that the homogeneity of the cast structure is improved; the readily soluble constituents dissolve and become more

(Continued on p. 184)

Starting Point For Better Melting

AJAX-NORTHRUP CONVERTER-TYPE FURNACES

20 KW. CONVERTER

STEEL

BRASS

These compact, efficient furnaces are used in all leading metallurgical laboratories, and by the major producers of precision castings.

"Almost every new alloy since 1916 started in an Ajax-Northrup furnace."

The 20 Kw. converter will melt 17 pounds of steel in 40 minutes. Maximum capacity is 30 pounds of steel, or 60 pounds of bronze. The larger 40 Kw. unit melts faster, will handle up to 50 pounds of steel. The 6 Kw. unit melts a pound of steel in 8 minutes.

All units may be used for heat-treating, forging, sintering or other applications—no problem to change from one to the other.

Ajax-Northrup converters are completely self-contained. They can be placed anywhere in your plant where water and power are available, require no special foundation or wiring — and they're certified to meet F.C.C. regulations.

Many of today's "blue chip" industries started with a 20 Kw. Ajax-Northrup converter.

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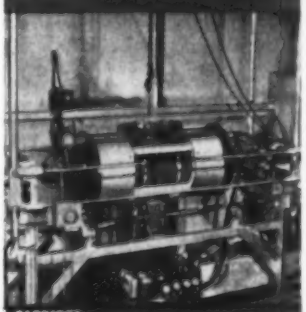
RESEARCH



CARBIDES

GOLD

AJAX NORTHRUP

INDUCTION HEATING AND MELTING

Since 1916

151

Large Pressings, Forgings and Extrusions

(Continued from p. 182)

uniformly distributed, and less soluble constituents spheroidize and agglomerate to form larger particle sizes. Changes of this type improve the hot working characteristics of an aluminum alloy, resulting in finer grain and more uniform mechanical properties in the finished product. Preheating becomes more important as ingot size is increased. Such furnaces must obviously be of sufficient size to handle large ingots; unusually long soaking times at preheating temperatures will also be required.

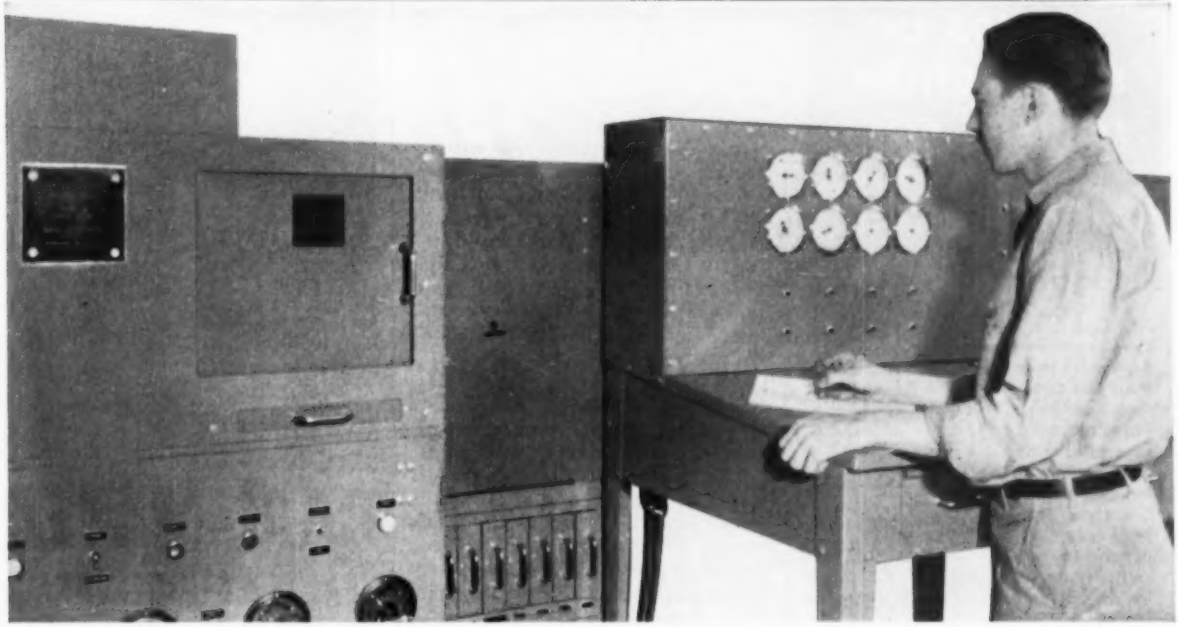
Furnaces for solution heat treating and aging must also be able to handle long lengths if adequate use is to be made of large extrusion presses.

In discussing the structure of large extrusions, Mr. McCormick referred to numerous studies which have been made to determine the character of metal flow during extrusion. This matter goes beyond academic interest as the size of the extrusion becomes larger. Applications of the knowledge gained from laboratory investigations has corrected some structural variations and removed certain defects peculiar to extrusions.

Such studies have demonstrated that the extreme front end of an extrusion receives little equivalent cold work, but the amount of cold work progressively increases along the extrusion's length. Under certain conditions, this results in a lengthwise variation of properties; the exact nature of the metallic structure depends on the working conditions, such as temperature, extrusion ratio, size and alloy. With large extrusions of the alloy types used for aircraft, the effects of each structural variation must be carefully evaluated with respect to mechanical properties.

The strong aluminum alloys do not recrystallize readily during extrusion or subsequent thermal treatments. With large sections, any recrystallization that does occur will be found in an outer surface layer which increases in thickness toward the rear of the extrusion. This recrystallized metal may be relatively coarse grained. For large 75S shapes, the entire cross section will have an unrecrystallized but highly worked structure which has a high degree of preferred orientation; thus, aluminum alloy extruded shapes have high longitudinal tensile and yield strengths – above those considered normal for shapes produced by other methods. *(Continued on p. 186)*

Rigidly controlled chemistry



Another reason why you get uniform, high-quality forgings with TIMKEN® forging steels!

YOU can be sure of uniform forgings when you use Timken® forging steels. That's because the quality of Timken forging steels is rigidly controlled, from melt shop all the way through final inspection, by the most precise methods known.

For example, the direct-reading spectrometer shown above chemically analyzes a molten heat of Timken forging steel in just 40 seconds. And a complete analysis report is given to the melt shop within 10 minutes! First of its kind in the steel industry, it's just one of the many ways the Timken Company controls quality at every step in production.

Your order for Timken forging steels is handled individually in our mills. We target conditioning procedure to your particular forging requirements. You can hold rejects to a minimum. And you save steel because the good dimensional tolerances of Timken steel forging bars produce uniform weight multiples with a minimum of steel lost in flashings.

You're assured of uniform physical properties, too, when you use Timken forging steels. They respond uniformly to heat treatment—from bar to bar and heat to heat. Fewer furnace adjustments are needed. And Timken forging steels have uniform grain size after heat treatment. Result: forgings made from Timken forging steels have uniformly high ductility and resistance to impact.

For help in improving the quality of your forgings and cutting production costs, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Large Pressings, Forgings and Extrusions

(Continued from p. 184)

Relatively thin sections receive more equivalent cold work during extrusion and are thus more completely recrystallized. For this reason aircraft specifications require higher tensile and yield strengths for the larger sections. However, with further increase in size of extrusion, other factors, such as decreased extrusion ratio and slower quench rate from solution heat treatment, tend to lower the mechanical properties. Larger extrusion presses will partially solve this problem.

As section size increases, properties in other directions – particularly transverse properties – become more important and aircraft designers strongly favor the establishment of minimum specifications for such properties. If extrusions are cold worked a slight amount by stretching prior to heat treatment, they may be completely recrystallized and thus the preferred orientation effects may be minimized.

Stepped extrusions have a critical point at the junction between two section sizes; at those portions the flow lines in the structure will be at an angle to the axis. This is a corresponding detriment to the longitudinal mechanical properties as compared with points distant from the step. However, the direction of metal flow corresponds closely to the direction of applied major stresses when the extrusion is used as a wing spar; thus, design values are not unusually impaired.

35,000-Ton Press*

IN A SPECIAL issue of its *News Letter*, E. W. Bliss Co. describes the general design of one 25,000 and one 35,000-ton hydraulic press ordered by the U. S. Air Force for a plant under construction at Newark, Ohio, to be operated by Kaiser Aluminum & Chemical Co. *(These are two units of a heavy press program discussed on p. 111 of this issue. In all, two 25,000-ton, four 35,000-ton, and two 50,000-ton forging presses are under order, as well as nine extrusion presses of 20,000-ton capacity or more. In addition to the E. W. Bliss Co., other builders of the presses include Baldwin-Lima-Hamilton Corp.,*

(Continued on p. 188)

*Review of *Bliss News Letter*, No. 14, November 1952, a special issue devoted to "Bliss Heavy Forging Presses".

35,000-Ton Press

(Continued from p. 186)

Hydropress, Inc., Mesta Machine Co., and the United Engineering & Foundry Co.)

This new Bliss equipment is to make large members such as wing spars and engine mounts for modern high-speed military aircraft, pressed of strong aluminum or magnesium alloys – parts which might otherwise be fabricated from many smaller pieces, or machined individually from large billets. Press forging in closed dies rather than hammer forging in open dies is preferred because of the much higher accuracy of the finished part; likewise impact forging is frowned upon for certain important alloys, such as 58S magnesium and 75S aluminum. Press dies can be accurately aligned, and their temperature maintained at optimum degree for proper plasticity of the alloy being forged. Die shops and heat treatment departments at the Newark forging plant are also of king size; the 35,000-ton press has clear opening 24 ft. long by 12 ft. wide by 11 ft. high; dies will be sectional and made up of blocks weighing 10,000 to 60,000 lb. Light alloy billets up to 24 in. diameter will be forged; heat treatment furnaces have hearths 55 ft. long by 24 ft. wide, are heated with radiant tubes and automatically controlled.

German presses of this size are towering oversized models of conventional presses; the big Bliss presses turn this upside down and place the actuating cylinders in a container *below* the stationary bed or base. This cylinder container moves up and down, and with it the upper crosshead or crown; container and crown are tied together with eight hollow rods, each 37 in. diameter, 70 ft. long, and weighing 8½ tons each. (The 25,000-ton press has four tie rods, each 47-in. diameter, and 70 ft. long, about the maximum which could be made by Bethlehem Steel Co.) Forging dies are hung from the underside of the crown and matching mates placed on top of the base. To handle these dies (as well as a 2500-ton horizontal press which can be placed within the operating space for operating double-action dies) the two big presses are placed on a single axis with a bridge between and appropriate sliding tables installed to serve the two.

Much of the *Bliss News Letter* has

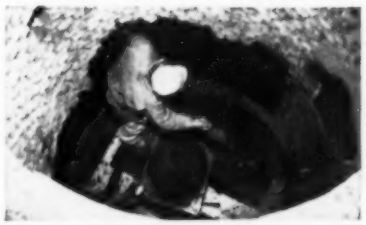
(Continued on p. 190)

Johns-Manville Insulations save industry a billion dollars in fuel every year!

Reduce your fuel costs and build better furnace linings with JM-3000 INSULATING FIRE BRICK

HERE'S THE ONLY insulating fire brick that withstands a full 3000F. It's highly efficient both as an exposed refractory lining or as back-up insulation. And JM-3000 is only one of six types of Johns-Manville Insulating Fire Brick made for these applications. All provide long-life insulation. All are light in weight, have low conductivity, high structural strength. These properties permit thinner furnace walls—yet you can achieve important fuel savings and increased production, because J-M Insulating Fire Brick assures quick furnace response.

Sil-O-Cel* Insulating Brick is another outstanding J-M fuel-saver . . . a high load-bearing brick for back-up insulation behind refractory linings. It comes in three types, for service through 2500F—makes it possible to reduce the necessary thickness of refractory linings as much as one-third.



Save fuel with J-M Hydraulic Setting Refractories

Johns-Manville refractories meet every need for castable, troweling and gunning applications for temperatures through 3000F. *Firecrete** is used to cast special shapes of all kinds. It is ready for use within 24 hours, has negligible shrinkage and high resistance to spalling. *Blazecrete** is used to build and repair furnace linings. When gunned, it adheres readily with a minimum of rebound loss. When slap-troweled, it eliminates laborious ramming and tamping.

Save Fuel with J-M Aggregates and Fills

These lightweight insulations are used as fills to conserve heat in irregular spaces where other forms of insulations cannot be economically applied. They are also used as aggregates for mixing with other materials to form insulating refractory concrete.

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Send for your free copy! This new booklet IN-115A gives full details about J-M insulating materials for service through 3000F. To find out how they can help cut your fuel costs, simply mail coupon.

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35,000-Ton Press

(Continued from p. 188)

to do with the problems of transporting and erecting the heavy sections. (An operating 1/16 scale model being constructed for stress analysis will have a capacity of 137 tons — not a small press itself!) Steel plates 10 x 80 in., 450 in. long, needed for the construction, approached the 44-ton limit of Lukens Steel Co.'s mill; even larger plates for the sliding tables are 12 ft. wide by 24 ft. long and 15 in. thick, and weigh 96 tons. These will be forged slabs.

Transportation and erection limitations require the subdivision of the crown, base and cylinder containers. Crown and base of the 25,000-ton press are in three pieces each; four for the 35,000-ton press. Generally speaking, construction will be of welded steel plate and castings; it is estimated that some 250 miles of single-pass welds will be needed to finish the 5 miles of joint, some in steel 15 in. thick. Maximum weight of a single subassembly is limited to 250 tons. The forge shop will have a 350-ton crane to maneuver the horizontal press auxiliary (the forging billets will be handled by manipulators) and erecting problems will be minimized because so much of the tall machines is below floor level.

The hydraulic system is equally important. Rapid motion is provided by 300-psi. water from prefill tanks. The pressing stroke is supplied at 1000 to 4800 psi. by water from high-pressure bottles in the pit near the press, in turn backed up by 54-ft. high air bottles near the pump room. This system is designed to be safe at 5400 psi.

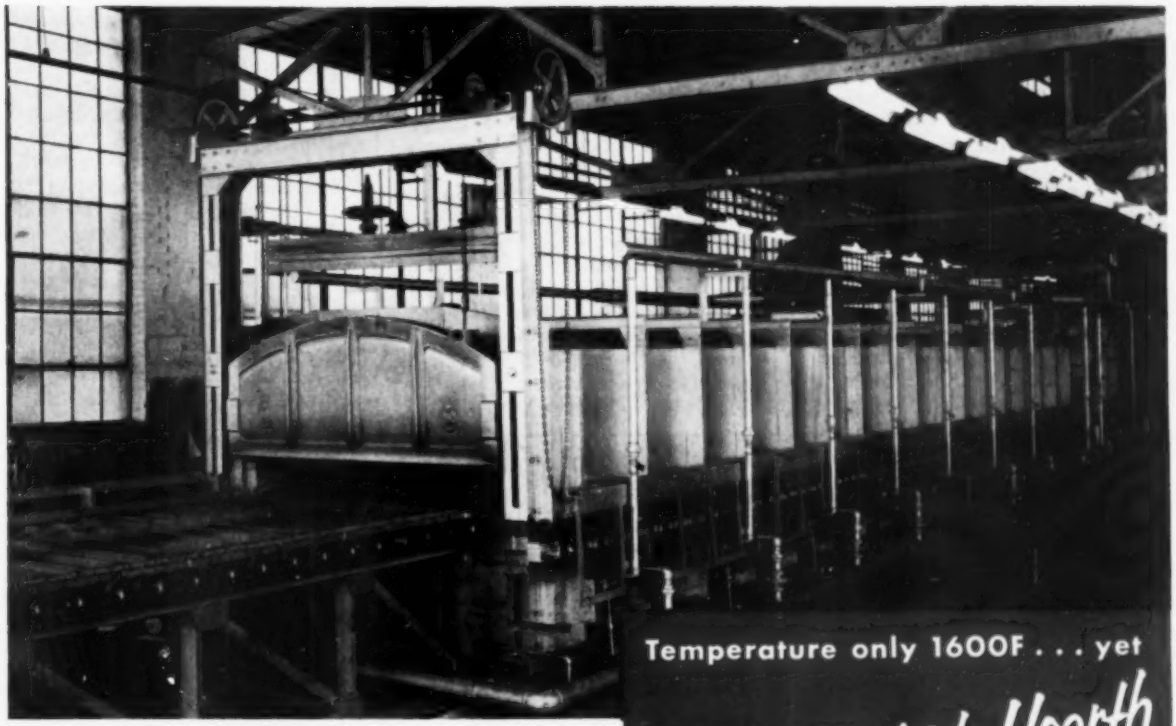
E. E. T.

Method for Representing Multi-Component Systems*

GEOMETRIC AND ANALYTIC methods have been used to represent the equilibrium conditions in multi-component metallic systems. A maximum of four components can be represented graphically in a straightforward manner in three-dimensional space, since there are three independently variable concentrations. More complex systems have been treated by methods involving multi-dimensional geometry by N. S. Kur-

(Continued on p. 192)

*Digest of "Method of Representation of Five-Component and More Complex Metallic Systems", by I. I. Kornilov, *Doklady Akademii Nauk SSSR*, Vol. 81, 1951, p. 191-194.



These armor-plate hardening furnaces, built by The Drever Co. of Philadelphia, Pa., range from 40′ to 60′ long, by about 7′ wide. There are seven furnaces like this operating at various plants. Each is equipped with a CARBOFRAX hearth. Average hearth life ranges from 18 to 36 months, depending on tonnage handled.

Temperature only 1600F . . . yet

Silicon Carbide Hearth Proves Best

Saves fuel . . . Heats more rapidly, and uniformly

This is a continuous roller-hearth hardening furnace, used for treating armor plates (up to 6′ wide, up to 20′ long, and in varying thicknesses up to 3″). It is under-fired with oil and/or gas to a chamber temperature of 1600 F. The work is carried on metal rollers over a hearth made of CARBOFRAX silicon carbide tile.

It is interesting that CARBOFRAX refractories were selected even though two of the outstanding properties of this material — its resistance to high temperatures and abrasion — are not brought into play. The reason for their selection, of course, lies in the tremendously rapid thermal conductivity of CARBOFRAX refractories. They conduct heat 11 to 12 times faster than fireclay. The result is a far more efficient furnace; one that heats uniformly, and can be closely controlled. It also takes less fuel — and the refractories are exceptionally long lasting.

This application brings home another point — i.e. not all silicon carbide refractories are the same. Other brands have been tried in similar furnaces, but due to premature oxidation, could not approach the life of these CARBOFRAX hearths.

Why Not Check Up? Chances are, your furnaces can be impressively improved by super refractories by CARBORUNDUM. Write or phone us today. Product data promptly furnished. Address: Dept. C-33, Refractories Division, The Carborundum Company, Perth Amboy, New Jersey.

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Trade Mark

"CARBORUNDUM" AND "CARBOFRAX" ARE REGISTERED TRADEMARKS OF THE CARBORUNDUM CO. — WORLD'S LARGEST MANUFACTURER OF SUPER REFRACTORIES

Method for Representing Multi-Component Systems

(Continued from p. 190)

nakov and co-workers. Often a geometric figure in a complex space, four-dimensional for example, can be projected to a less complex space, such as a three-dimensional one, for ease of interpretation. Another method of decreasing the complexity of the problem is to replace two variables by their ratio.

The present method is designed to describe the region of existence of solid solutions, which are of great industrial importance. Essentially the method consists in plotting along the x, y, and z-axes three of the components of an n-component alloy; the remaining $n-3$ components of the solid solution are plotted as one of several possible ratios at the origin of the plot. With increase in the amounts of the first three components, these $n-3$ decrease in amount but remain in the original ratio. The result is a three-dimensional figure that shows the region of solid solution and the two-phase fields that form the limits of solid solubility with increasing amounts of the three components being plotted.

As an example, a six-component iron-base alloy of the heat resistant type can be considered. It is possible to plot at the origin the point 15% chromium, 20% nickel, balance iron, a composition that forms an austenitic solid solution. A fourth element, A, can be plotted along the x-axis to increase in amount from zero to some maximum amount that exceeds the solubility of the austenitic solid solution. To compensate for this increasing amount of A, the amount of iron can be decreased accordingly. Alternatively the ratio of chromium-nickel-iron can be kept constant and the sum of the three can be decreased to compensate for the increase in A. Similarly, elements B and C can be plotted along the y and z-axes.

A. G. Guy

Vapor Deposited Coatings for Titanium*

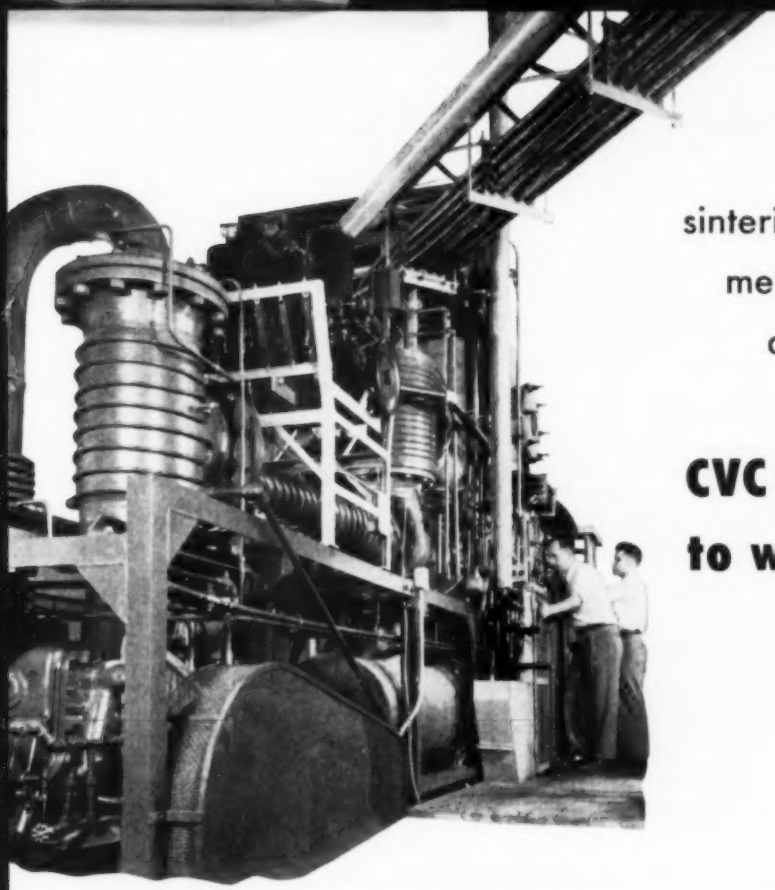
THIS REPORT concerns the development of a set of conditions for depositing molybdenum coatings on titanium metal using the general method of vapor deposition as outlined by Battelle Memorial Institute's Bulletin No. R-108 dated July 1948, and R-137 dated March 25, 1949, and by Lander and Germer in an article published by American Institute of Mining and Metallurgical Engineers in Technical Publication 2306, September 1947. The molybdenum plating was accomplished by the thermal decomposition of molybdenum carbonyl using hydrogen as the carrier gas, the process being best described by the relations:

$$Mo(CO)_6 \rightarrow Mo + 6CO$$
$$2CO \rightarrow C + CO_2$$

An additional step in the process, as developed by the authors, involved the use of vacuum during the initial heating period to prevent the oxidation of the titanium sample. In addition, continued evacuation of the entire system during the plating process served to remove the gaseous reaction products. The degree of vacuum attained during the initial stages of the process is not reported. The plating experiments concerned a series of tests in which the temperature of the sample, the decomposition pressure and the composition of the reacting gases were varied in an

(Continued on p. 194)

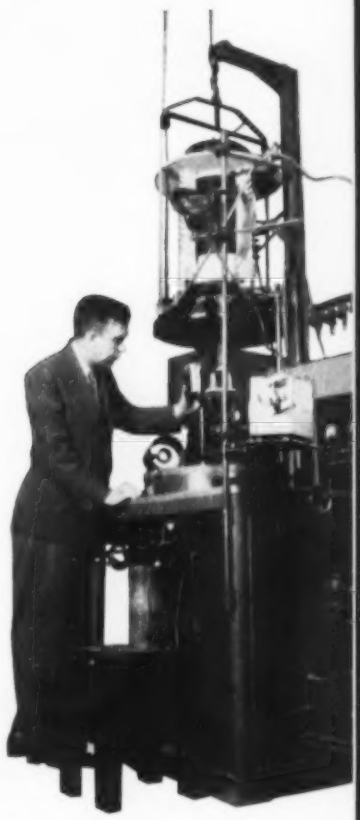
*Digest of "Research and Development of Methods of Vapor Deposited Coatings for Titanium and Titanium Alloys; Final Technical Report", Report No. 401/48/B-10, prepared by Sam Tour & Co., Inc., for Watertown Arsenal.



sintering
melting
annealing or
casting . . .

CVC can put high vacuum to work for you

This high vacuum furnace at Climax Molybdenum Company sinters, melts, and casts malleable, ductile "moly" in half-ton ingots. A uniquely economical CVC oil ejector pump creates the vacuum in the sizable chamber needed and gets rid of the gases evolved.



The Mineral Products Division of the National Bureau of Standards uses a CVC high vacuum furnace to study phase equilibria of binary and ternary metal-ceramic mixtures. Operating at 10^{-4} to 10^{-5} mm Hg, the furnace heats to 1800°C in ten minutes.

When you get rid of every possible molecule of air in a chamber, some very useful things happen.

For one thing, at pressures of 1×10^{-4} mm Hg, oxygen content is reduced to as little as 3 parts per billion. Casting, sintering, annealing, and purifying oxygen-sensitive metals is simplified. And it is usually easier and cheaper to get rid of oxygen than trying to dilute it.

Moreover, the negligible thermal conductivity in vacuums of this order makes heating faster, high temperatures easier to hold.

To make high vacuum a practical, economical metallurgical process, CVC has combined its own years of experience in solving high vacuum problems with expert manufacturing experience in metal-heating problems. We can supply vacuum furnaces with provisions for interchangeable furnace assemblies, sight windows, addition cups or whatever you need—and still hold high vacuum. And we know the answers to such problems as furnace insulation under vacuum, handling of volatile components of the melt, designing for trouble-free operation and ease of maintenance.

Whether you are interested in a high vacuum furnace for volume production or research, in vacuum dehydration, or in a single pump, we welcome the opportunity to talk with you. Just write or phone **Consolidated Vacuum Corporation, Rochester 3, N. Y.** (A subsidiary of Consolidated Engineering Corporation, Pasadena, Calif.) Sales offices: Menlo Park, Calif. • Chicago, Ill. • Camden, N. J. • New York, N. Y.

CVC

formerly DPi Vacuum Equipment Dept.

Consolidated Vacuum Corporation

Rochester 3, N. Y.

high vacuum research and engineering

Vapor Deposited Coatings for Titanium

(Con'inued from p. 192)

attempt to produce an adherent molybdenum coating.

Apparently the physical properties of the coatings are governed to a great extent by the amount and the form of the carbon contained in the deposited coating. High carbon deposition, resulting from the decomposition of the CO gas, is promoted by increased CO pressures; that is, a low H_2:CO. A high H_2:CO ratio, on the other hand, tends to minimize carbon deposition in the plating. The amount of deposited carbon can be reduced to a certain extent by using a higher sample temperature or lower CO pressure. However, there are certain limitations on the temperature and pressures which can be used.

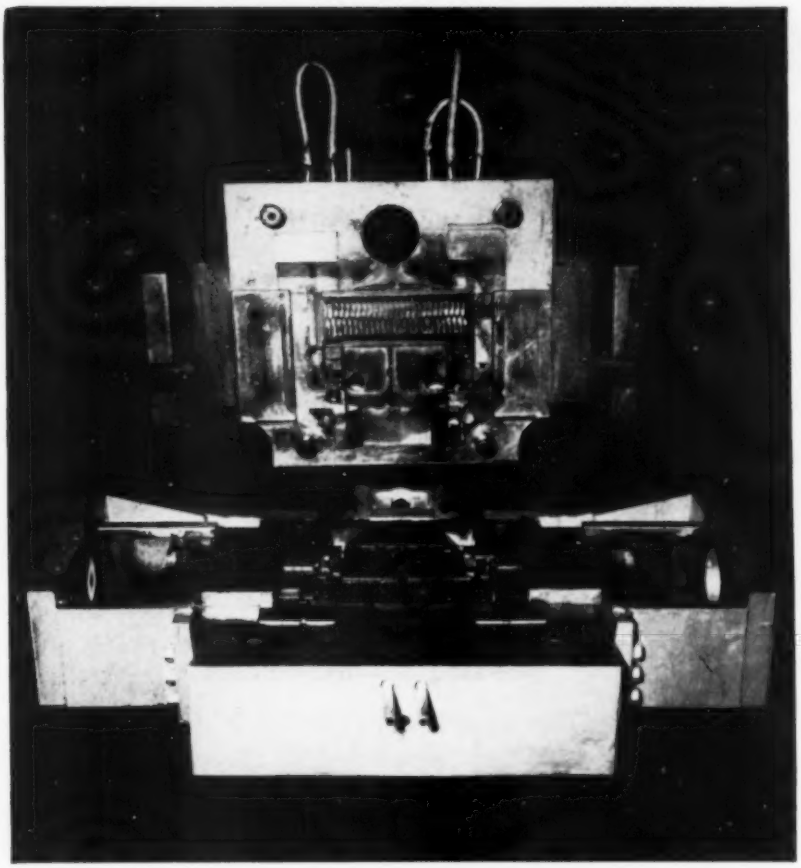
Excessive temperature may cause premature decomposition of the carbonyl gas, giving a nonadherent powdery deposit; low CO pressures reduce the plating rate and extend the plating cycle. Under the conditions by which this work was carried out, the best coatings were obtained at a temperature of 930° F. for the specimen and a gas mixture consisting of approximately 2 parts H_2 to 1 part CO by volume.

Determination of the chemical and physical characteristics of the resulting plate were not attempted in this work except with regard to hardness. Adherence characteristics of the plate were evaluated only in the respect that it withstood rough handling in sectioning or that it did not peel when subjected to hardness measurements. Plating thickness, as measured on micrographs, varied from 0.002 to 0.005 in. for a plating cycle of 6 hr. The uniformity of the coatings is not reported.

Considerable differences occurred in plate hardness through its cross section. This was attributed primarily to carbon deposition resulting from decomposition of the CO gas. Diffusional treatments at elevated temperatures resulted in grain growth and decreased plate hardness, but apparently did not materially affect the adherence of the plate or its bonding strength.

In general, this work has served to extend the general principles of vapor deposition to the specific problems of obtaining a molybdenum plating on commercial titanium metal. The characteristics of these deposits and their application in industry are yet to be determined.

R. G. Ulrech



No matter what your DIE-CASTING JOB may be...

Accuracy calls for POTOMAC M Hot Work Die Steel

"HOT-WORK STEELS"

is the title of a new, six-page folder that tells about the chromium, molybdenum, vanadium Hot Die Steel known as POTOMAC M—and also covers other grades for other hot-work operations. Secure your copy —*write today!*

ADDRESS DEPT. MP-39

In the precision casting of aluminum, POTOMAC M Hot-Work Die Steel is especially favored as the material for die-casting dies because its properties help assure accuracy of the steel itself *after* heat treatment. Die makers have found that size changes are held to a minimum. Dimensional stability is thus the *first* contribution that POTOMAC M makes to accuracy.

Production accuracy of the die after it is in service is maintained also by the resistance of POTOMAC M to wear, to heat checking, and to metal wash.

Allegheny Ludlum makes a complete line of steels for hot-work tooling of various kinds—so, whether your need is the mass producing of duplicate parts or fabricating a few of them, call up or write "A-L" every time for hot-work counsel or service or both. Just tell us your requirements.

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For complete **MODERN** Tooling, call

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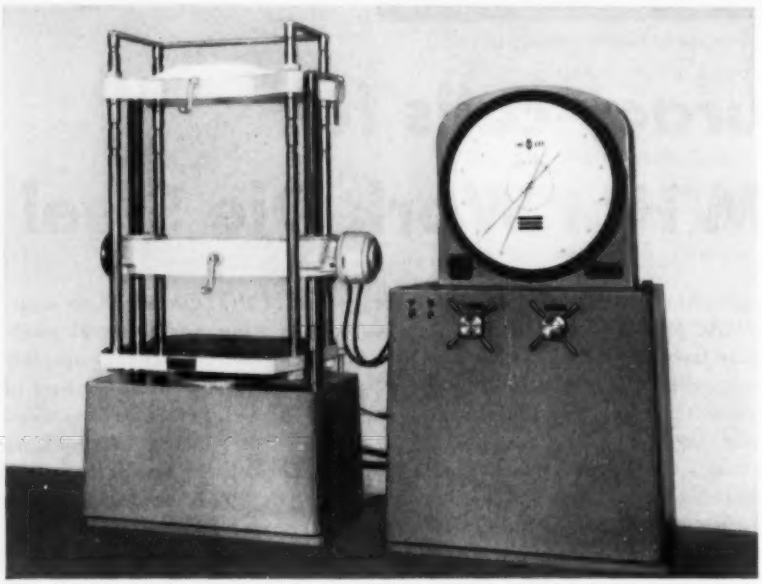

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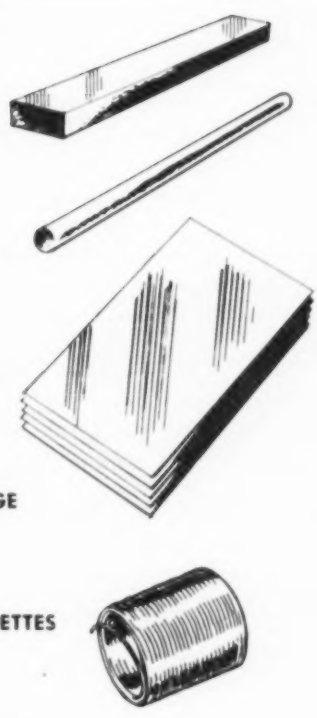

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1. **QUICK ACTING** . . . Cleans and dries in record time. And after rapid degreasing of surfaces, metal is warm, dry and ready for further processing.

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Make sure your metal parts are 100% grease-free. NIALK TRICHLORethylene leaves them clean, warm, dry, ready for immediate electroplating, painting, enameling, lacquering, rustproofing, heat treating, pickling, inspection or assembling.

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UNICHROME
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Specifications on corrosion resistance met by these
Two Ways to Chromate-Finish Zinc

ZINC FINISH STAYS BRIGHT AS CHROMIUM

Zinc plate, when chemically treated in Unichrome Clear Dip and then fortified with a Unichrome Clear Enamel, provides a substitute finish which can satisfy exacting requirements. The Clear Dip forms a bright-as-chromium finish integral with the zinc, while the clear enamel adds extra wear and corrosion resistance to this protective finish without detracting from its brightness. This successful finishing system is in widespread use today on zinc die cast and steel products.

CLEAR ENAMEL SAVES THOUSANDS OF DOLLARS

A clear enamel over today's decorative chromium finish gives extra protection against moisture, handling, corrosives. Using a special Unichrome Coating, one well known manufacturer is getting not only superior protection on plated refrigerator shelves, but also greater film thickness at less cost than the coating formerly used. Savings reported for the year: $15,000.

Better Protection Against Chemical Attack

Because Ucilon* Protective Coatings resist many strong chemicals, they're being used today in a wide variety of tough applications. On plating machines, for example. Also on bottling machines and on processing equipment. Use of these coatings means less corrosion and better appearance with less maintenance. Ucilon Coating Systems are available to withstand acids, alkalies, salt solutions, oxidants, moisture, petroleum products, alcohols, fumes and other corrosives. Write for Bulletin MC-4.

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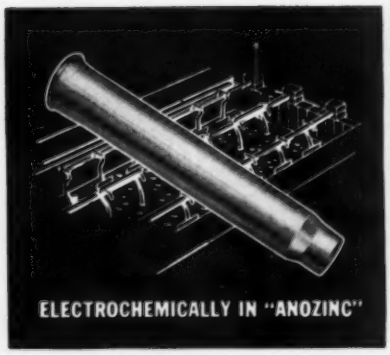
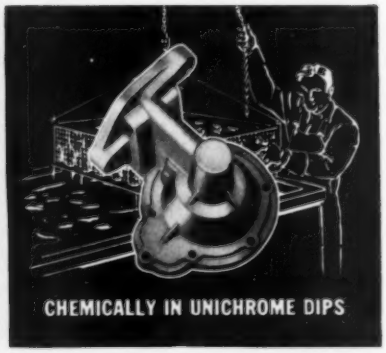


ELECTROCHEMICALLY IN "ANOZINC"



CHEMICALLY IN UNICHROME DIPS

■ Government specifications which call for chromate treating of zinc plate, do so to assure protection against corrosion. Several methods of chromate finishing are available to do this job. This gives the user freedom to choose the particular process that's best suited to his product, and offers production or cost-cutting advantages.

Two Unichrome Processes are widely used today because they can not only meet or exceed specifications, but also provide substantial benefits to the user.

A TOUGHER COATING THROUGH ANODIZING

The Anozinc* process, using conventional plating equipment, produces black, yellow or clear chromate type coatings on zinc plated parts by means of current. An exclusive process, it provides a finish with not only the desired corrosion resistance, but also superior toughness while still wet. This means that parts can be handled at once, thereby minimizing the storage and drying space problem.

The Anozinc process can be set up in one continuous automatic cycle with the zinc plating, or for manual operations. Zinc plated steel shell cases are being turned out at a fast clip with this process, as are propeller blades and other vital work.

In forming conversion coatings, chromate treatments remove some of the zinc from the product. Consequently, there is a problem in recessed areas of the work, where zinc plates thinner than it does at the edges. Not with Anozinc, however. An anodizing process, it complements the zinc plating process. Its stripping action is less in recesses where the zinc plate is thin. With a straight chemical dip, more zinc would have to be deposited to compensate for non-selective stripping action.

UNICHROME DIP A SIMPLE PROCESS

Unichrome Dip Finishes, chemically produced, are adaptable for manual or automatic operation. They too inhibit corrosion and withstand exposure. Different solutions produce a black, olive drab, brass-yellow, iridescent yellow or clear chromate coating in 5 seconds to 2 minutes, depending on the solution used. These finishes, integral with the zinc surface, also make excellent bases on which to apply organic coatings.

As straight chemical processes, Unichrome Dips use simple equipment, need no generator or rectifier and minimize installation costs.

Unichrome Dips produce bright, glossy finishes. The black and olive drab finishes can provide the eye appeal of glossy enamel. Clear finishes are bright, and have an appearance similar to chromium.

BOTH ARE ECONOMICAL SOLUTIONS

Anozinc baths have exceptionally long life. Unlike chemical dips, they seldom need to be discarded. In mass production, this feature cuts operating expenses.

Compared with other dips, Unichrome Dips can save money, too. By using a Unichrome Dip instead of their "home made" chromate dip, one well known company cut cost of materials alone by one-third.

Write for Bulletin CC-1, or phone the nearest United Chromium office.

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A Customer Reports:

"We use Continuous-Cast Bronze because of its Uniform Quality"

MANNING, MAXWELL & MOORE, INC., (Shaw-Box Crane and Hoist Division) Muskegon, Michigan, manufacturers of cranes, hoists and specialties, says also that ASARCO bronze lends itself admirably to production on automatic screw machines.

ASARCO Continuous-Cast Bronze is used for the gear center of the brake gear in this company's "Budgit" portable electric hoist because its high physical properties far exceed those of ordinary foundry or mill products. Stock is consistently uniform in size and quality. Porosity is non-existent.

Since the patented ASARCO continuous casting process excludes sand, dirt, dross and other impurities, there are no inclusions in ASARCO bronzes to injure tools or reduce high cutting speeds. Rejects are virtually unknown . . . machining on automatics is standard practice.

All stock for machining is Medart-straightened and furnished within a general tolerance of +0.004" to −0.006" on outside diameters. Tube concentricities are within 1.5% of wall thickness.

Continuous-Cast Bronzes are made to order in a wide variety of alloys . . . in standard lengths of 12' . . . lengths 5' to 12' on request . . . lengths 12' to 20' by special arrangement.

216 sizes and shapes of standard Asarcon 773 bearing bronze (SAE 660) are stocked in 105" lengths for convenience at warehouses in principal cities across the country. Distributors will cut this stock long or short to suit your needs.

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That's only part of Hoskins' product picture, though. Other specialized quality-controlled alloys developed and produced by Hoskins include: Alloy 785 for brazing belts; Alloy 717 for facing engine valves; special alloys for spark plug electrodes; Alloy 502 for heat resistant mechanical applications. And, of course, there's Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.

Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.

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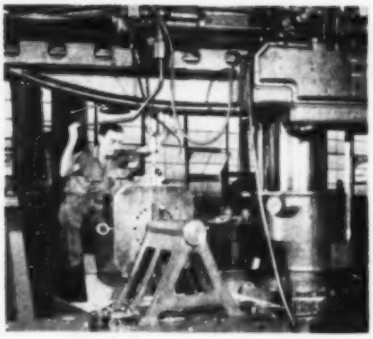

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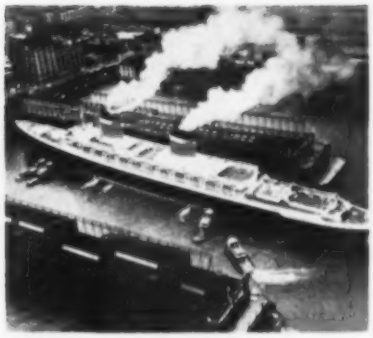

Plates and shapes—For high strength and superior weldability, designers of the U. S. liner, *United States*, specified hull plates of vanadium steel. Besides increasing strength and ductility, vanadium decreases any tendency toward undesirable brittleness in the welded zones even at subzero temperatures.

Castings—Crawler shoes for power shovels, bucket teeth for dredging machinery, truck frames for railway cars—all have increased strength, greater resistance to shock and fatigue when cast from vanadium steel. These castings also have excellent machining qualities and can be heat treated to a wide range of mechanical properties.

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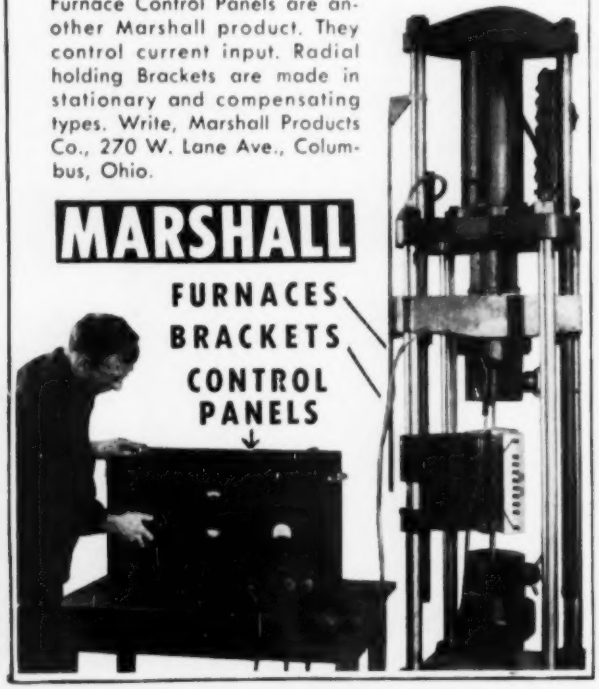

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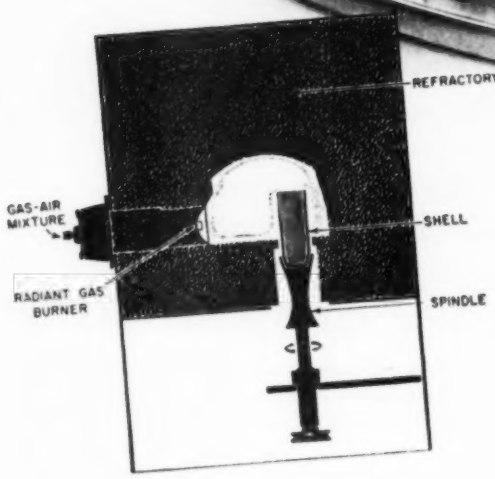

Shells are rotated while on a dial type conveyor. Spindle height is designed to allow the heating only of that section which is subsequently tapered.

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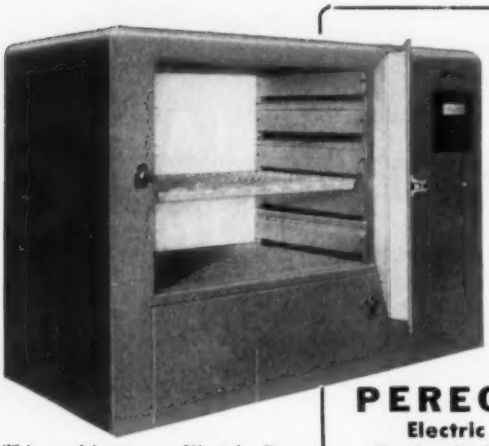

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District Managers

John F. Tyrrell and John B. Verrier, Jr.
55 W. 42nd St., New York 18—CHickering 4-2713

Ralph H. Cronwell
482 Burton Ave., Highland Park, Ill.—Highland Park 2-4263

Donald J. Billings
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